AD-A076 333 ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY ROCK ISLAND IL F/G 9/2
SURVEY OF COMPUTER AIDED MANUFACTURING SYSTEMS WITHIN DARCOM. F--ETC(U)
SEP 79 A C ADLFINGER

UNCLASSIFIED NL

1 OF 2
ADA
076333

LEVEL

US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND

AD A076333

CAM SYSTEMS

SURVEY OF COMPUTER AIDED MANUFACTURING SYSTEMS WITHIN DARCOM

U.S. ARMY
DARCOM

DISTRIBUTION UNLIMITED, DOCUMENT FOR PUBLIC RELEASE

SEPTEMBER 1979

PREPARED BY THE

MANUFACTURING TECHNOLOGY DIVISION

US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY

79 11 07 011

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER FIRST CY 79	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) 6 SURVEY OF COMPUTER AIDED MANUFACTURING SYSTEMS WITHIN DARCOM.	5. TYPE OF REPORT & PERIOD COVERED 9 21 June 1977 — 31 July 1979 Biannual Survey
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 Mr. Albert C. Adlfinger	8. CONTRACT OR GRANT NUMBER(s) N/A
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army Industrial Base Engineering Activity ATTN: DRXIB-MT Rock Island, IL 61299	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS N/A
11. CONTROLLING OFFICE NAME AND ADDRESS US Army Industrial Base Engineering Activity ATTN: DRXIB-MT Rock Island, IL 61299	12. REPORT DATE 11 September 1979
	13. NUMBER OF PAGES 136
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) US Army Materiel Development & Readiness Command ATTN: DRCMT, Office of Manufacturing Technology 5001 Eisenhower Avenue Alexandria, VA 22333	15. SECURITY CLASS. (of this report) UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A

16. DISTRIBUTION STATEMENT (of this Report)

DISTRIBUTION UNLIMITED

12 149

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

DISTRIBUTION UNLIMITED

18. SUPPLEMENTARY NOTES

N/A

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer Aided Manufacturing
Manufacturing Methods and Technology
CAM Audit
CAM Survey
DARCOM

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document is the result of a survey of the CAM History, Active and Planned Efforts, and Projected CAM Needs within DARCOM. The information included in this survey was submitted to IBEA from DARCOM major subordinate commands, installations and activities. Summaries of active and completed CAM projects are included in two appendices.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

410 713

DEPARTMENT OF THE ARMY
US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY
ROCK ISLAND, ILLINOIS 61299

DRXIB-MT

4 OCT 1979

SUBJECT: Survey of DARCOM Computer Aided Manufacturing (CAM) Systems

SEE DISTRIBUTION

1. Reference is made to DARCOM-R 15-13, "DARCOM Computer Aided Manufacturing (CAM) Steering Group," dated 3 June 1977.

2. This document contains the results of a Survey of CAM systems being used by DARCOM elements. The survey was prepared by IBEA under the auspices of DARCOM-R 15-13 and will be updated biannually as a reference source for evaluating the progress being made by DARCOM in applying CAM technology.

3. Additional copies of this report may be obtained by written request to the Defense Documentation Center, Attn: TSR-1, Cameron Station, Alexandria, VA 22314.

James W Carstens
JAMES W. CARSTENS
Acting Director
Industrial Base Engineering Activity

Accession For
NTIS GRA&I ✓
DDC TAB
Unannounced
Justification

By
Distribution/
Availability Codes
Dist | Avail and/or special
A

TABLE OF CONTENTS

EXECUTIVE SUMMARY

A. Survey Results

DARCOM Major Subordinate Commands

In the Major Subordinate Commands, most of the NC/CAM activities were reported by one Readiness command, ARRCOM, and by the Development Commands. The other readiness commands; CERCOM, TSARCOM, and TARCOM indicated no CAM involvement. The following Development commands showed CAM involvement; ARRADCOM, ERADCOM, NARADCOM, TARADCOM, MIRADCOM, AVRADCOM, MERADCOM, and CORADCOM. DESCOM completed an internal study of NC/CAM equipment and published results in August 1979.

ARRCOM

CAM efforts at the time of this report, were most active in the metal working arsenals and in approximately one half of the ammunition plants.

Arsenals

The metal working arsenals, Rock Island Arsenal (RIA) and Watervliet Arsenal (WVA), have increased their number of Numerically Controlled (NC) machine tools from one (1) in the late 1950's to 50 NC machine tools at RIA and 65 NC machine tools at WVA. Along with these increases in numbers of NC machine tools, the arsenals have progressed from; manual programming of NC machine tools, through automatically programmed tool (APT) processors, to computer supported processors. Rock Island Arsenal installed a Direct Numerical Control (DNC) system in 1971, which controlled and monitored the operations of five NC Machine Tools. Cathode ray tubes located at each machine and in the programming department were used to conversationally generate part programs at the machine site as the machine was being run. Recently RIA has installed and used successfully Computerized Numerical Control (CNC) which uses a dedicated minicomputer to control motions of a single NC machine.

Ammunition Plants

Army ammunition plant functions are generally categorized into four manufacturing areas; propellants and explosives (PE); metal parts (MPTS); load, assemble and pack (LAP); and, small arms (SA). Plants having CAM applications are shown at the top of the next page.

AMMUNITION PLANTS INVOLVED IN CAM

	Plant	PE	MPTS	LAP	SA
Active AAPs:	Crane			X	
	Holston	X			
	Indiana	X		X	
	Iowa			X	
	Lake City				X
	Lone Star	X		X	
	Louisiana		X		
	Radford	X			
	Scranton		X		
In-Active AAPs:	Badger	X			
	Joliet	X			
	Newport	X			
	Twin Cities				X
	Volunteer	X			

The greatest CAM efforts in the propellant and explosive ammunition plants have been in converting batch processes to continuous processes (e.g. continuous nitration process, etc.). These continuous processes have in most cases been totally automated to enhance productivity, timeliness, and safety of production. Full evaluation of most of these automated process systems cannot be made until larger work loads are available. However, all line operations run at partial capacities have proven successful.

The load assemble and packaging ammunition plants have successfully applied CAM to manufacturing lines in order to handle parts, monitor and control production, and perform tests and inspections. The computers are being applied to continuous manufacturing of single-based propellant by assigning one computer for direct digital control (DDC) and another backup computer performing in a dual-redundancy mode ready to assume control should the first computer fail.

One projectile metal parts ammunition plant, Scranton, has applied CAM to production lines by providing programmable material handling. Louisiana AAP has successfully concentrated on improving production by procuring fourteen (14) industrial robots for handling metal parts. Mostly the projectile metal parts plants have concentrated their efforts mainly on acquiring and operating NC machine tools.

In general, Ammunition Plants, which have acquired NC machine tools, are improving CAM capabilities through the application of computer controls and minicomputer controls. Computers are also providing management information on production, testing and inspections through reports and displays on video terminals.

ARRADCOM

The manufacturing facilities at ARRADCOM headquarters Dover, NJ, includes twenty-eight NC machine tools which were moved from Frankford Arsenal in 1977 when Frankford Arsenal was combined with Picatinny Arsenal. ARRADCOM CAM facilities include the combined NC machine tools, APT programming systems, computer numerically controlled (CNC) machine center and computer supported interactive graphics system from Picatinny and Frankford Arsenals.

ERADCOM

Harry Diamond Laboratories (HDL) acquired its first NC machine tool in 1962. Additional equipment acquired since that time have included three NC Machine Tools, a minicomputer to control cordax inspection equipment, several computer aids used in engineering design, a minicomputer base APT (UNIAPT) system, a computer vision (CV) mechanical parts layout design system, an NC Drill and an automatic scanner to digitize hand drawn printed circuit boards. Additionally almost all CAM resources were transferred from ECOM to ERADCOM in 1977 when ECOM was reorganized into the three new commands; ERADCOM, CORADCOM, and CERCOM.

NARADCOM

NARADCOM has CAM applications in two areas of design. The first is the standardization of clothing design and the second is the standardization of helmet design. NARADCOM successfully installed and operates a complete computer processing system for clothing designing. The system has the capability of digitizing a master pattern, processing numerical data to provide all sizes of clothing required, and plotting or cutting all sizes on standard pattern cardboard. Designing clothing in this manner has reduced the cost of pattern fabrication, improved accessability to data storage and improved Army clothing quality. The second area of CAM application, the standardization of Army helmet design, has not been completed.

TARADCOM

TARADCOM began utilizing NC machine tools for milling, drilling, and gas-metal arc welding work processes in 1963. Recently, CAM techniques have been applied in designing and manufacturing blocker and finisher dies for forging track shoes and links. TARADCOM now has a major effort on going to apply Flexible Machining Systems (FMS) in small production runs.

AVRADCOM

AVRADCOM has developed computer programs to design and manufacture extrusion dies that optimize the extruding process of aluminum, titanium and steel structural parts.

MIRADCOM

The Technology Laboratory indicates it had been active in CAM during the DARCOM CAD-E program and it is continuing several of these activities. A Multi-Station Mechanical Design System (MSMDS) is operational for parametric and detail design. Also, automatic nondestructive test methods have been developed.

MERADCOM

MERADCOM reported one NC Tape Drill/Mill 3 axis machine which was acquired in 1967. This machine has successfully increased manufacturing efficiency, produced more precise parts and reduced manufacturing costs. Additional expansions in NC/CAM applications are not anticipated.

DESCOM

The Depot Systems Command (DESCOM) reported five depots actively using a total of twenty two numerically controlled machine tools. DESCOM submitted no detailed report since it was conducting a depot wide NC/CAM study which was to be completed and distributed in August 1979. The Depot Study provides a complete listing of specific NC/CAM equipment for each depot indicating equipment conditions, controls, and operating criteria.

B. Findings

Most DARCOM installations expressed an interest in being apprised of CAM state of the art on a continuing basis.

Major applications of CAM appear to be in the arsenals, ammunition plants and the development commands. Very little CAM effort was indicated in the other installations. Future expansions in CAM were predicted but will be subject to the availability of funds. Future CAM applications will include micro-processors for manufacturing equipment control, energy management systems, scheduling, and inventory systems.

The information included in this report serves as an initial base to describe the extent of CAM involvement in DARCOM. Future inputs will build on this data.

INTRODUCTION

Background

The Department of the Army Materiel Development and Readiness Command (DARCOM) Computer Aided Manufacturing (CAM) Steering Group was established in 1977 as an advisory board to the Chief, Office of Manufacturing Technology and the Associate Director for the Industrial Base of HQ's DARCOM. This CAM Survey is meant to support CAM planning and consists of an initial compilation of the CAM involvement within DARCOM. The data was submitted from DARCOM Major Subordinate Commands, Installations, and Activities. DARCOM Regulation 15-13 dated 3 June 1977 provides the authorization for publishing and updating the CAM planning.

Objective

The objective of this survey was to:

- o Provide an initial inventory of current DARCOM CAM systems.
- o Provide an analysis of the application CAM technology and equipment.
- o Provide a source document for interservice exchange of CAM information.

Scope

The scope of this report was limited to the information submitted to IBEA from Major Subordinate Commands, installations, and activities. The letters requesting the CAM information are shown in Appendix B.

Information requested for this analysis report fell into two main categories:

- o Names of assigned CAM Steering Group representatives. (Reference letter dated 21 June 1977 in Appendix B.)
- o A narrative discussion describing CAM facilities, equipment, and software at each installation. (Reference letter dated 18 April 1978 in Appendix B.)

Methodology

The CAM Survey was carried out in three phases.

- o Phase I - Disseminating letters, see Appendix B, requesting names of assigned CAM representatives and requesting a description of CAM facilities, equipment and software.
- o Phase II - Collecting and reviewing the data submitted to IBEA and following up where data was insufficient.

Methodology (cont'd)

- Phase III - Analysis of the data and formulation of the CAM final report.

RESULTS

The survey results are structured into two main sections.

A. Summary listing indicating types of responses received by IBEA.

B. Analysis of the narrative responses submitted by each replying organization.

A. Summary List of Responses

Section A is composed of a listing indicating the summary of types of responses submitted by each replying organization. Section A is organized into two listings. The first list is a summary representing Major Subordinate Commands. The second list depicts Major Subordinate Commands and their Installations.

The types of responses which were submitted are categorized by the five columns described below.

1. Replied - Indicates a written response was submitted to IBEA.

2. Representative - Indicates a CAM Steering Group representative name was submitted to IBEA.

3. Interested - Indicates a written response was submitted expressing involvement or interest in CAM.

4. Narrative - Indicates a written response describing CAM involvement was submitted to IBEA.

5. Office/Officer - Indicates replying Office/Officer for written response to IBEA.

A. SUMMARY LIST OF RESPONSES by DARCOM MAJOR SUBORDINATE COMMAND

Command	Replied	Representa-tive	Interested	Narrative	Office/Officer
ARRADCOM	X	X	X	X	Dir, Tech Support Dir.
ARRCOM	X	X	X	X	Act. Dep. Dir. Ind. Readiness Directorate
AVRADCOM	X	X	X	X	Dir. of Dev. and Engrg.
CERCOM	X	-	-	-	Ch, Readiness Prog. Div, Logistics Eng. Directorate
CORADCOM	X	-	X	X	CORADCOM/DRDCO-AM
DESCOM	X	-	X	X	Commander, Sacramento AD
ECOM	X	X	X	-	Ch, Prod Div. Proc. & Prod. Directorate
ERADCOM	X	X	X	X	Ch, Res. & Engrg. Spt. Div.
MERADCOM	X	X	X	X	Ch, Engr. & Logistic Mgt Office
MIRADCOM	X	X	X	X	Dir, GE&MS Directorate Tech. Lab
MIRCOM	X	X	X	-	Dir, Engineering Lab
NARADCOM	X	X	X	X	Chief, MIS Office
TARADCOM	X	X	X	X	Dir, TARAD Lab
TARCOM	X	X	X	-	Dir. of Proc. & Prod.
TECOM	X	-	-	-	Dir. of Mgt Info System
TROSCOM	-	-	-	-	-
TSARCOM	X	X	X	-	Ch, Prod. Engrg Branch
USAILCOM	X	-	-	-	Dir. Systems Dev.

Notes:
- X Indicates information was received by IBEA.
- \- Indicates no information was received by IBEA.

A. SUMMARY LIST OF RESPONSES by DARCOM MAJOR SUBORDINATE COMMAND AND INSTALLATIONS

Command	Replied	Representative	Interested	Narrative	Office/ Officer
ARRADCOM	X	X	X	X	Dir, Technical Spt. Division
Chemical Systems Lab	X	X	X	-	Chf. Developmental Spt. Division
Picatinny Facilities	X	-	X	X	ARRADCOM, HQ
Frankford Facilities	X	-	X	X	ARRADCOM, HQ
Ballistic Research Lab	-	-	-	-	-
ARRCOM	X	X	X	X	Act. Dep. Dir, Industrial Readiness Directorate Mgt Into Sys Dir - Chief S&E Sys Division
ARSENALS					
Frankford Arsenal	X	-	-	-	Civilian Deputy
Pine Bluff Arsenal	-	-	-	-	-
Rock Island Arsenal	X	X	X	X	Arsenal Operations Dir.
Rocky Mountain Arsenal	-	X	-	-	-
Watervliet Arsenal	X	X	X	X	PP&C Division NC Coordinator, Opts Systems Office

Notes:
- X Indicates information was received by IBEA.
- \- Indicates no information was received by IBEA.

A. SUMMARY LIST OF RESPONSES
by
DARCOM MAJOR SUBORDINATE COMMAND AND INSTALLATIONS

Command	Replied	Representative	Interested	Narrative	Office/Officer
ACTIVE ARMY AMMO PLANTS					
Crane AA Activity	X	-	X	X	Engineering Directorate
Hawthorne AAP	-	-	-	-	-
Holston AAP	X	-	X	X	CDR, Holston AAP
Indiana AAP	X	X	X	X	Chief Engineer/Cdr
Iowa AAP	X	X	X	X	Cdr Iowa AAP
Kansas AAP	X	-	-	-	Adjutant, Kansas AAP
Lake City AAP	X	-	X	X	Cdr, Lake City AAP
Lone Star AAP	X	X	X	-	Chief, Engrg. Division
Contractor	X	-	X	X	Day & Zimmermann, Inc.
Longhorn AAP	X	-	-	-	Acting Commander
Louisiana AAP	X	-	X	-	Chief Engineer
Contractor	X	-	X	X	Thiokol, General Manager
McAlester AAP	-	-	-	-	-
Milan AAP	X	-	-	-	Executive Officer & Commander
Mississippi AAP	-	-	-	-	-
Radford AAP	X	X	X	X	Commander

Notes:
X Indicates information was received by IBEA.
- Indicates no information was received by IBEA.

A. SUMMARY LIST OF RESPONSES
by
DARCOM MAJOR SUBORDINATE COMMAND AND INSTALLATIONS

Command	Replied	Representative	Interested	Narrative	Office/Officer
ACTIVE AAP's (cont'd)					
Riverbank AAP	X	X	X	X	Commander
Scranton AAP	X	X	X	X	Commander
Ethan Allen Firing Range	-	-	-	-	Commander
IN-ACTIVE ARMY AMMO PLANTS					
Alabama AAP	-	-	-	-	-
Badger AAP	X	X	X	X	Commander's Rep
Cornhusker AAP	X	-	-	-	Commander's Rep
Gateway AAP	-	-	-	-	-
Hays AAP	X	-	-	-	Commander's Rep
Joliet AAP	X	-	X	-	Industrial Specialist
Contractor	X	-	X	X	Uniroyal, Plant Manager
Newport AAP	X	-	-	-	Chief Engineer
Ravenna AAP	X	-	-	-	Plant Engineer
St. Louis AAP	-	-	-	-	-
Sunflower AAP	X	-	X	-	Commander's Rep
Contractor	X	-	X	X	Hercules Inc., VP & General Mgr

Notes:
X Indicates information was received by IBEA.
- Indicates no information was received by IBEA.

A. SUMMARY LIST OF RESPONSES
by
DARCOM MAJOR SUBORDINATE COMMAND AND INSTALLATIONS

Command	Replied	Representa-tive	Interested	Narrative	Office/ Officer
IN-ACTIVE ARMY AMMO PLANTS (cont'd)					
Twin Cities AAP	X	-	-	X	Commander's Rep
Volunteer AAP	X	X	-	-	Commander's Rep
Contractor	X	-	X	X	ICI America, Inc; Plant Manager
Phosphate Dev. Works	-	-	-	-	-
AVRADCOM	X	X	X	X	
Contractors					
Boeing Vertol	-	-	X	X	Dir. of Dev. & Engrg
Sikorsky Aircraft	-	-	X	X	Dir. of Dev. & Engrg
Bell Helicopter	-	-	X	X	Dir. of Dev. & Engrg
Hughes Helicopter	-	-	X	X	Dir. of Dev. & Engrg
CERCOM	X	-	-	-	Chf, Readiness Prog Div. Logistics Eng Directorate
CORADCOM	-	-	-	-	-
Ft. Monmouth	X	X	X	X	CORADCOM/DRDCO-AM
DESCOM	X	-	X	X*	Commander & Comp Sacramento AD
DEPOTS					
Anniston AD	X	-	-	X*	Comptroller
Corpus Christi AD	X	X	X	X*	Deputy Dir of Maint

Notes:
x Indicates information was received by IBEA.
- Indicates no information was received by IBEA.
* Indicates the five Depots mentioned in one letter from DESCOM.

A. SUMMARY LIST OF RESPONSES
by
DARCOM MAJOR SUBORDINATE COMMAND AND INSTALLATIONS

Command	Replied	Representa-tive	Interested	Narrative	Office/ Officer
DEPOTS (cont'd)					
Letterkenny AD	X	X	X	-	Dir. for Maintenance
New Cubmerland AD	-	-	-	-	-
Red River AD	-	-	-	-	-
Sacramento AD	X	X	X	X*	Dir. for Maintenance
Seneca AD	-	-	-	-	-
Sharpe AD	X	-	-	-	Dir. for Admin. & Serv.
Sierra AD	-	-	-	-	-
Tobyhanna AD	X	X	X	X*	Deputy Dir. for Maintenance
Tooele AD	X	X	X	X*	-
DEPOT ACTIVITIES					
Lexington-Blue Grass ADA	X	-	-	-	Dir. for Mgt. Info. Sys.
Navajo ADA	-	-	-	-	-
Pueblo ADA	X	-	-	-	Commander
Savana ADA	X	-	-	-	Chief, Mission Division
Umatila ADA	X	-	-	-	Commander
Ft. Wingate ADA	-	-	-	-	-
ECOM	X	X	X	-	Ch, Prod Div. Proc & Prod Directorate

Notes:
- X Indicates information was received by IBEA.
- \- Indicates no information was received by IBEA.
- * Indicates the five Depots mentioned in one letter from DESCOM.

A. SUMMARY LIST OF RESPONSES
by
DARCOM MAJOR SUBORDINATE COMMAND AND INSTALLATIONS

Command	Replied	Representative	Interested	Narrative	Office/ Officer
ERADCOM	-	-	-	-	-
Harry Diamond Laboratories	X	X	X	X	Ch, Res. & Engrg
Night Vision Laboratories	-	-	-	-	-
MERADCOM	X	X	X	X	Ch, Engr. & Logistic Mg Office/Dir.
MIRADCOM	X	X	X	-	Dir, GE&MS Direct. Tech Lab
NARADCOM	X	X	X	X	Chf, Mis Office & Chf, Engrg Programs Management Office
TARADCOM	X	X	X	X	Dir, TARAD Lab
TARCOM	X	X	X	-	Dir, Procurement & Production
TECOM	X	-	-	-	Dir, Mis
TROSCOM	-	-	-	-	-
TSARCOM	X	X	X	-	Ch, Prod. Engrg. Branch
USAILCOM	X	-	-	-	Dir. Systems Dev.
DARCOM - PROJECT/ PRODUCT MANAGERS, LAB, SCHOOLS, & OTHER INSTALLATIONS/ACTIVITIES					
PM-PBM	X	X	X	-	Deputy Proj. Mgr. Mun Prod Base Mod. & Exp.
Army Maintenance Management Center	X	-	-	-	Ch, Mgt Info Sys, Division

Notes:
- X Indicates information was received by IBEA.
- \- Indicates no informatin was received by IBEA.

A. SUMMARY LIST OF RESPONSES
by
DARCOM MAJOR SUBORDINATE COMMAND AND INSTALLATIONS

Command	Replied	Representa-tive	Interested	Narrative	Office/ Officer
Army Mgt Engrg Trng Act. (AMETA)	X	X	X	-	Director
Army Mat. & Mech Res Ctr (AMMRC)	X	X	X	X	Assoc Dir, Plans & Prog
Army Research Office	X	-	-	-	Administrative Officer
Auto Log Mgt Systems Activity	X	-	-	-	Dir. of ADP Tech
Joint Military Pkg Trng Ctr	X	-	-	-	Ch, Admin & Log Office
Logistics Sys. Support Act.	X	-	-	-	Chief

Notes:
X Indicates information was received by IBEA.
- Indicates no information was received by IBEA.

B. Analysis of Responses

Section B is composed of the analysis of the narrative responses submitted by each replying organization. Section B is organized into subsections, each representing a Major Subordinate Command arranged in alphabetical order.

The narrative discussion on each DARCOM element is analyzed in three separate categories; (1) CAM history, (2) Active and Planned Efforts and (3) Projected CAM Needs.

B. ANALYSIS OF RESPONSES
DARCOM MAJOR SUBORDINATE COMMANDS

ARRADCOM

The Armament Research and Development Command (ARRADCOM) headquartered at Dover, NJ, along with large-caliber and small-caliber mission support has command elements of the Chemical Systems Laboratory and the Ballistics Research Laboratory at Aberdeen Proving Ground, MD, and the Benet Weapons Laboratory at Watervliet, NY.

1. CAM History

The manufacturing facilities at Headquarters, Dover, NJ, includes the combined NC equipment of Picatinny and Frankford Arsenals. Both arsenals acquired NC machine tools around the late 1950's, expanded to APT programming systems, and implemented an Interactive Graphics system on a computer. Picatinny acquired its first CNC K & T 4-Axis machining center in 1975. In 1977, Frankford Arsenal personnel and equipment began to move to Picatinny. Frankford Arsenal had acquired a total of twenty-eight NC machine tools before being moved to Picatinny.

The following is a brief chronology of CAM activities at these two installations prior to organization of ARRADCOM.

Picatinny Facilities

- o 1959 - An NC machine tool feasibility study was conducted for manufacturing planning.
- o 1961 - The first NC machine, a Burgmaster Drill, was acquired and installed. Prior to establishment of ARRADCOM, fifteen additional NC machines were procured. The advantages of NC operation were confirmed.
- o 1962 - As NC operations expanded and the APT programming language became available, Picatinny became a leader in this field. This Arsenal was designated the Army member of the APT Long Range Program for maintenance and further development.
- o 1970 - A CDC 6500 computer was installed and the APT programming language was implemented to greatly expand NC capability.
- o 1973 - A further significant development in APT was achieved with the implementation of APT Interactive Graphics on the CDC computer.
- o 1975 - The first CNC K & T 4-Axis machining center was acquired and installed. This was the start of a new modernization program.
- o 1977 - Frankford personnel and equipment began the move to Picatinny.

Frankford Facilities

o 1960 - NC machining at Frankford Arsenal began with procurement of K & T Model II - 3 - Axis milling machine. Since then, twenty-eight NC machines were installed to provide a well balanced manufacturing capability.

o 1973 - A stand-alone, minicomputer UNIAPT programming system was installed for rapid tape preparation and verification with post processors for all NC machines. To satisfy the demand for military items of increasingly greater complexity and higher accuracy in limited quantities at lower cost, the NC equipment and computerized support functions were structured into a total manufacturing system. Experience has proven an average productivity ratio of 3.4 to 1 and very significant reductions in hard tooling costs and set-up times compared to non-computerized operations. This fully integrated CAM system represents an investment of approximately 5-million dollars.

o 1975 - A computerized Interactive Graphics System including hardware and software was acquired and merged with the original UNIAPT system. Additional computer core was added and the disc storage expanded with a 10-platter disc drive. To further enhance the system, a high speed plotter was added.

o 1976 - Distributed Numerical Control (DNC) was initiated with five Computer Controlled Multiplexer with expansion capability to 32 machines. This practically eliminates the requirement for tapes other than for long term program storage.

o 1977 - In the last half of 1977, the transfer of equipment and personnel to ARRADCOM, Dover, NJ, was expedited. The total relocation of all CAM operations was accomplished in 1978.

2. Active and Planned Efforts

In the manufacturing activity (Technical Support Directorate) there are currently three Interactive Graphics Terminals utilizing Frankford's General Automation MOD-1665 Computer with 32K of core and a 10-platter disc drive. The system is inadequate. A project has been submitted for FY79 to acquire six additional terminals and a high speed new generation eclipse 230 minicomputer. The new minicomputer will also function as a satelite to the CDC 6500/6600 computer.

Currently available Group Technology Systems were reviewed with vendors and numerous system users. This effort was for a procurement specification in support of an MMT project. The completed purchase description included a proviso that the proprietary system be made available to all Department of Army activities without additional cost other than systems application training.

Active and Planned Efforts (cont'd)

Based on the survey, a contract was awarded. The computerized Group Technology System is installed and being implemented at ARRADCOM.

Other Army installations are encouraged to make arrangements with ARRADCOM for use of this proprietary system. Contact at ARRADCOM is Stanley S. Hart; (AV) 880-3721/3472, Coml (201) 328-3721/3472.

3. Projected CAM Needs

The development of Group Technology Software programs for Computer Classification and Coding of an item being drawn on the Interactive Graphics Terminal is needed. The code number would determine the NC machine group and execute the applicable post processor for the designated machine. Scheduling software would determine the workload on the designated machine, its earliest availability, and provide an estimated delivery date. The funding requirement for this effort is being developed.

ARRADCOM's software will enable an engineer to access the group technology system interactively via the graphics terminals. Output would include classification and coding of the needed item.

ARRCOM

The Armament Materiel Readiness Command (ARRCOM) headquartered at Rock Island, IL, directs the operations of four assigned arsenals (Rock Island, Watervliet, Pine Bluff, and Rocky Mountain); 28 assigned Government owned, contractor-operated (GOCO) ammunition plants and Army ammunition activity; the DARCOM Ammunition Center; the Central Ammunition Management Office-Pacific (CAMO-PAC); and the US Army Technical Escort Unit.

1. CAM History

In November 1976, DARCOM requested ARMCOM and Ft. Eustis to submit a plan to greatly reduce or eliminate computer usage at the Midwest S&E Computer Center at AVSCOM. The IBM 360-65 being utilized there was saturated and it became increasingly difficult to support prime time processing requirements.

After evaluating four possible alternatives, it was agreed the most cost effective way of achieving the goals was to purchase a minicomputer for local S&E requirements. A plan was submitted to DARCOM in December of 1976.

Following approval of the plan by DARCOM and research into minicomputer technology, a Request for Proposal was issued in June of 1977.

On 30 November 1977, the contract was awarded and in January of 1978 a minicomputer system designated the Prime 400 and manufactured by Prime Computer, Inc. was installed at ARRCOM.

CAM History (cont'd)

The Prime 400 is a multifunctional system. For example, users can simultaneously develop application software, execute batch command files, handle data input, emulate a hasp workstation for sending jobs requiring special software to an IBM 360/65, execute interactive programs, and perform disk and tape file utilities. The operating system automatically and transparently allocates all real system resources among the users.

The Prime 400 supports three types of file access - sequential, direct, and index sequential. Two levels of file security are also provided. File handling procedures are the same regardless of the type of disk being used or the type of software program.

2. Active and Planned Efforts

Plans are presently being finalized to expand this system to include up to 3 smaller minicomputers connected in a satellite configuration so that files and processing workload can be shared.

3. Projected CAM Needs Headquarters ARRCOM did not reply.

Arsenals

The arsenals for many years have been energetically pursuing computer Aided Manufacturing while continually upgrading their facilities.

The Rock Island Arsenal (RIA) and Watervliet Arsenal (WVA), in the late 1950's, obtained their first NC machine tools. Since that time, the Rock Island Arsenal has acquired 50 numerically controlled (NC) machine tools while Watervliet Arsenal has acquired 65 NC machine tools.

Both arsenals experienced the evolution of acquiring computer support in the late 1960's.

ROCK ISLAND ARSENAL

1. CAM History

Rock Island Arsenal (RIA) installed its first NC machine tool in 1958. In-house computer support came in 1966 when the Arsenal Operations Directorate (AOD) installed an automated data collection system. Seventy-five terminals located in nine buildings were used to transmit production and labor information to a Control Data 106A computer which generated production status and labor efficiency reports. This same system drove the Arsenal's cost accounting and customer billing systems. In this type of system, the prime advantages realized were timeliness and the keypunch cost savings which resulted from using data collection output without modification.

In 1971, RIA installed a Direct Numerical Control (DNC) system called Sundstrand Omnicontrol. In this system a Digital Equipment Corporation PDP-11/20 computer controlled and monitored the operations of five NC machine tools. Cathode ray tubes located at each machine and in the programming department were used to conversationally generate parts programs and then optimize those programs at the machine site as the machine was being run.

CAM History (cont'd)

The DNC system eliminated manual programming resulting in an estimated savings of between $75,000 and $100,000 yearly. Also, the DNC computer allowed RIA to take it's first step towards a good production and inventory control (P&IC) system. Under a CAM contract, the IIT Research Institute developed programs for the PDP-11/20 computer designed for utilization monitoring and job history monitoring. The success of this system gave RIA its first exposure to the potential of on-line processing and lead to additional work on P&IC.

More recently, RIA had its initial exposure to a new technology called Computerized Numerical Control (CNC). This systems uses a dedicated minicomputer, PDP-8 to control the motions of a single NC machine. Many of the traditional electro-magnetic elements of a conventional NC system have been replaced by software and initial success with this system at RIA indicates a bright future for CNC. In some respects, CNC systems are similar to computerized coordinate measuring machines which are inspection devices that have been used at this Arsenal for years.

2. Active and Planned Efforts

In 1973, RIA began work on a program called PASLACS (Pilot Automated Shop Loading and Control System) which promises to solve most of RIA's P&IC problems. A commercial software package marketed by Informatics, called Production IV, was installed on the local IBM 360/65 computer allowing RIA to increase the productivity of its entire direct labor work force and thereby reduce the cost and production leadtimes for all of its products. The PASLACS program, is planned as a standard production tool at RIA.

The RIA AOD plans to buy a terminal with access to the ARRCOM-S&E computer for use by the Plant Engineering staff.

Three NC controls for three existing American Lathes and one new unit for a Kearney & Trecker Turn-12 Machine are programmed for acquisition in. These control units are to replace units which have developed operational problems, making them expensive/unreliable to use.

The FY-79 project will develop the application of Group Technology, including computer utilization. This is a planned two year effort.

During the FY-80 program, the first year of a three year series, a Shop Floor Feedback System is planned to develop a shop-floor/computer-interactive capability. This system is intended to replace the present punched card work-measurement Transactor system. Presently proposed for acquisition in FY-80 are:

One NC sheet metal punch and nibble machine
Two vertical profilers (double spindle)
Some (quantity undertermined) NC turret lathes
Four NC 4-axis shaft lathes

Active and Planned Efforts (cont'd)

The majority of all available resources have been concentrated on PASLACS. Contributions have involved proofing, testing, modifying, and upgrading the capabilities of the Production IV system and integration of this system into an Arsenal-Government environment. Also involved has been the necessity of interfacing a production control system with the Army's depot production support module Speedex system.

3. Projected CAM Needs

Additional CAM technology development efforts that would benefit RIA but are yet unfunded include:

A system for using a computer for the development of labor standards. With improved system for setting standards; productivity, productivity improvement, work scheduling, staffing requirements, etc., can be more effective.

Computer Assisted Process Planning is an area within which RIA has no present effort. Another productive venture would include Optimal Process Planning. This involves computerizing the sequencing of operations as related to material flow in the shop, referred to as a flexible floor manufacturing system. There are several potential avenues for investigation here.

A computer system for the selection of replacement equipment would be beneficial. At the present time, the equipment buy decisions are more intuition, based on samples or the opinions of a limited group of people. A computerized system would enable a more objective basis for decision making.

Preprocessors upgrading involving Adaptive Control would be desirable. This involves using the computer to establish machine tool cutting speeds and feed as the result of in-process measurement of such factors as tool force, motor power consumption, chip temperature, etc., to maintain a near optimum condition for machining at all times.

WATERVLIET ARSENAL

1. CAM History

Watervliet Arsenal (WVA) purchased its first NC equipment in 1960. At the present time, WVA has a total of 65 NC machine tools consisting of 20 machining centers, eight drills, fourteen profiling machines, 11 lathes, seven vertical turret lathes, two shapers, two CAM mills and one rotary forge.

The first experience of processing NC part programs using automatically programmed tool (APT) processor with in-house computer support was in 1970 with the IBM 360/44 computer located in Benet Weapons Laboratory. This arrangement had serious drawbacks in that the IBM software was not compatable with the IBM executive system. It was necessary to replace the basic executive system with the APT processor and run the APT part program submittals during the

CAM History (cont'd)

second and third shifts. This caused programmers to handle the same program up to six work days before they would have it ready for prove out.

In December 1974, a commercial time sharing contract with McDonnell Douglas Automation Company (McAuto) was finalized and has been renewed on a yearly basis ever since. This method is adequate and has reduced tape preparation time to one or two work days. However there are some typical disadvantages which include; excessive cost, lost jobs, transmission errors, inability to communicate with the system during peak utilization time periods, and lack of a back-up system. Because of these disadvantages, WVA determined that the procurement of an in-house stand-alone system is the most economical as well as the most practical method to achieve the desired autonomous capability while able to adapt to future developments.

2. Active and Planned Efforts

Funding has been received in the amount of $218,450 for the purchase of an NC tape preparation and verification system for program tapes. This combination of hardware and software will give Watervliet Arsenal a full stand alone, in-house APT processing capability for NC part programming. A year-by-year contract will be maintained for a completely compatable back-up tape processing system by means of the prior McAuto remote time sharing agreement. Additional CAM developments and equipment under investigation considered to be a benefit to Watervliet Arsenal are:

- o Require that CNC controls be furnished with the purchase of new NC machines and also when present machines are retrofited with new controls. These controls should be designed with a complete package of diagnostic aids, both resident and non-resident, to minimize down-time. (One example of this type of control would be the Mark Century 1050).
- o Purchase NC Grinding Machines
- o Initiate an Interactive Graphics System
- o Develop standardization of spindle sizes to improve interchangeability and reduce tool holder inventory.

3. Projected CAM Needs

The WVA Modernization Program will have a significant impact on the NC facilities. It is anticipated that by FY85, the total compliment of NC machine tool inventory will increase from the present 65 to 141 machines. Plans are formulated for the next FY to procure six CNC lathes, two CNC three-spindle profilers, and two CNC two-spindle profilers.

Army Ammunition Plants (AAP)

Of the seventeen active AAP's ten (or 59%) indicated, through narrative reply, that they are currently involved or have been involved in CAM applications. In addition, five (or 38%) of the thirteen inactive AAP's also indicated that they were either currently involved or had been involved in CAM efforts.

Army Ammunition Plants (AAP) (cont'd)

The majority of the AAP involved with utilizing CAM began their acquisitions of computers, machine tools and processing equipment in the late 1960's and in the early 1970's. However, Holston AAP, through its operating contractor, initiated an automatic process control system as early as 1958.

In the Mid 1960's the United States Army made a decision to begin modernization of the batch TNT Lines. This modernization involved replacing the old World War II vintage batch TNT Lines with a new continuous nitration process. Radford AAP, in the mid 1960's, was the first plant to install the new continuous process line. In the late 1960's and early 1970's, ten more continuous process lines were installed; two at Radford AAP, five at Newport AAP, and three at Joliet AAP. The new process was later modified, utilizing remote Direct Digital Control (DDC), and was successfully installed at the Volunteer Army Ammunition Plant.

Extensive new application of CAM to all Army Ammunition Plants at this time appears to be restrictive due to workload reductions causing acquisition, justification, and maintenance problems, during active and inactive cycles. Where larger workloads permit, CAM has been successfully applied in the Ammunition Plants to such areas as tool manufacturing, general machine shop, controlling of ammunition manufacturing, testing, alarm systems, spare parts, and general tool inventory procurement control systems.

The CAM equipment used by the Army Ammunition Plants covers a large spectrum of available types ranging from numerical control machine tools, controllers, main frame computers, time sharing computers, minicomputers and software to automated material handling equipment, robots and continuous visual and pressure detection.

Future requirements indicated by the Army Ammunition Plants include acquisition of micro-processors for manufacturing equipment control, energy management systems, total scheduling, inventory and maintenance systems and blast, fire alarm and control systems.

In summary, the Army Ammunition Plants which indicated upgrading of their production capabilities through the use of CAM applications are shown on the following page.

Army ammunition plant functions are generally categorized into four manufacturing areas; propellants and explosives (PE); metal parts (MPTS); load, assemble and pack (LAP); and, small arms (SA). Plants having CAM applications are shown at the top of the next page.

AMMUNITION PLANTS INVOLVED IN CAM

	Plant	PE	MPTS	LAP	SA
Active AAP's:	Crane			X	
	Holston	X			
	Indiana	X		X	
	Iowa			X	
	Lake City				X
	Lone Star	X		X	
	Louisiana		X		
	Radford	X			
	Scranton		X		
In-Active AAP's:	Badger	X			
	Joliet	X			
	Newport	X			
	Twin Cities				X
	Volunteer	X			

Active Army Ammunition Plants

CRANE ARMY AMMUNITION ACTIVITY

1. CAM History

The first NC machine was installed at Crane in 1965. From 1965 through 1976 the NC Department has grown to ten pieces of equipment. Of these ten pieces of equipment, four were purchased new and six were obtained through D.I.P.E.C. This equipment ranges in capability from two axis point-to-point to four axis contouring.

2. Active and Planned Efforts

One CNC Lathe is in the process of being procured.

The problem with a continuing modernization program in the NC field at Crane is lack of availability of workload beyond 12 months.

The APT system is used at Crane and primarily done manually, however, computer support is available within 48 hours.

3. Projected CAM Needs

A computer system for the selection of replacement equipment would be beneficial. Much of the industrial equipment at Crane was manufactured during the 1940's. Efforts to obtain new equipment on intuition based on samples or the opinions of a limited group of people have been rejected. Most of the industrial equipment at Crane exceeds the economic life as established by "Information for Preparation of Economic Analysis" furnished by ARRCOM. CAM Technology development efforts in the form of replacing worn and older equipment with CNC equipment could improve the efficiency of the Industrial Shops at Crane.

HOLSTON ARMY AMMUNITION PLANT

1. CAM History

Holston Defense Corporation (HDC), contractor-operator for Holston Army Ammunition Plant (HSAAP), installed its first automatic process control system in 1958. The system was used to automate an HMX batch nitration process. The system was later duplicated and reduplicated to control two more HMX batch nitrations. All three of these are still functional.

In 1976 a new central building was constructed to prepare hexamineacetic acid solution - a basic raw material for explosive production. The entire control system (conditional logic, sequencing, and process control algorithms) was done with a Data General NOVA computer with backup. All functions have been checked using simulated conditions and each was satisfactory. A total production scale check-out cannot be done until higher production rates are required.

2. Active and Planned Efforts

The three CYPAK control systems for batch HMX nitrations are scheduled for replacement in the next FY budget. The old system is totally out of date and spare parts are slow on delivery and high in cost. The replacement project will also consider more up-to-date innovations for control of the processes.

3. Projected CAM Needs No reply.

INDIANA ARMY AMMUNITION PLANT

1. CAM History

a. Background

Black powder has been almost entirely replaced by other explosives. The need for black powder remains, however, in selected items such as igniter pads and fuses. The one remaining plant at Moosic, Pennsylvania is over 60 years old and in danger of being shut down for health and safety reasons. Hence, the US faces a potential lack of domestic black powder. The planned in-house facility at Indiana AAP is intended to remedy this situation.

b. CAM Acquisitions

In 1973, a Foxboro FOX 2/30 Integrated System using SPEC 200 and a programmable controller interface was purchased. In 1974, construction was begun on a new manufacturing facility at the old vacant plant #2 location. By the end of 1977, physical construction of the buildings and secured area was essentially complete and installation of the process equipment was well under-way. Black Powder prove-out was begun in November 1977 with funding and full effort commencing in February 1978.

The prove-out phase of the new equipment is projected for completion in December 1979.

2. Active and Planned Efforts

It is forseen that when this facility is completed it will be capable of meeting all necessary black powder mobilization requirements.

Throughout the entire process the materials are transported by conveyor and handled by automated equipment. The computer and the programmable controllers with the aid of closed loop sensor feedback circuits control the quantity and the quality of the end product during the whole manufacturing procedure. In the process control center the operation is displayed on a process flow panel with sensor condition lights which flash when a fault condition occurs, an audible alarm tone is sounded and all or portions of the process are brought to a halt until the fault is cleared and the controllers are reset by the operators.

In addition, there is a Honeywell Alpha 3000/Delta 2000 computerized fire alarm system which supervises the sprinklers and monitors the reservoir level, pressure and the deluge system sensors. This system is located in the guard facility for continuous surveillance and has automatic fault and ground detection with line switching, alarms and print-out of summaries and logs. This system has a "press-to-test" capability.

Like the deluge system, both computers are powered by uninterruptable power sources for continuous service during a general power failure. It is anticipated that the two computers will be interfaced to allow fire protection and monitoring in the process control center.

Probably the most significant result of the R&D effort in building this facility is the development of the "Harperizer" to replace the glazing barrels. The Harperizer uses continuous-flow glazing instead of the batch method increasing output and safety. The later results from reduced concentration of explosive material during glazing.

When completed, initial production of Black Powder is estimated at 500,000 lbs/mo on a single shift basis using a staff of 25 operators.

3. Projected CAM Needs No reply.

IOWA ARMY AMMUNITION PLANT

1. CAM History

Computer-Aided Manufacturing (CAM) has played a rather limited role at this Installation during the past several years. Initial CAM progress was tied very closely to the efforts of the Atomic Energy Commission (AEC, now ERDA) when it maintained a Plant at Iowa's Line 1 facility. Unfortunately, much of the technology left with the AEC in 1975.

In an indirect manner, the computer has proven itself as an aid to manufacturing because of its essentiality in management information systems. At this Installation, the business computer is drawn upon to support several management systems.

The Cost Schedule Control System (CS/CS) measures performance in terms of definitive accomplishments relative to planned schedule and cost objectives, while it institutes and maintains positive integrated schedule, cost and work scope control.

The Maintenance Information System provides performance, coverage, and scheduling information as it pertains to maintenance-type personnel.

The production Materials Management Information System revised parts of the Army Contract Material System to allow material requisitions, Purchase Orders, and inventory data to be captured and played back against product/part schedule requirements. "Budgeted/Actual" System allows the comparing of budgeted cost figures to actual cost figures.

Two other informational systems used at this Installation are the Project-Milestone System and the Lifting Devices System. The former provides a display, by project, of the time-phasing and work milestone requirements of various projects. The latter assists in accomplishing the requirements of the safety inspection and testing of lifting devices throughout the Installation.

The Quality Division, in 1973, installed remote terminals for use by inspector personnel for density and gap calculations on explosive charges and for general data storage. Also in 1973, Digital Equipment Corporation (DEC) PDP-8 Computers were placed in two Installation production buildings. One unit was installed in Building No. 1-40 to gather data from four gages on a time-shared basis. This data was subsequently formatted and printed out for inclusion in permament weapons records. The second unit was installed in Building No. 1-80 to control and monitor mass properties equipment supporting production of various weapons configurations. The Installation Quality Division also utilized a DEC PDP-8 in Building No. 1-12 during 1975 to control

a hole location gage. These systems were removed from the Installation after ERDA (AEC) left in 1975. In July 1975, a process controller for manufacturing was brought into use in the TOW and Dragon Warhead processing. Still in use today, this system controls the completely automatic, three-hour conditioning cycle. Alarm and data acquisition capabilities are also provided.

A small process controller is used to manage the operations of an automatic 90MM crimp machine which radially crimps a cartridge to the body of a shell. Continuous monitoring is utilized to afford operating personnel various safety features.

The production of M55 Detonators has been enhanced by the addition of the in-house designed "X4 Multi-Tooled Loader". A central process controller enables this machine to provide visual readout of consolidation heights and pressures with manual setpoints for reject parameters. Also provided are various safety features such as a blast detector which senses any detonator blow and automatically shuts down the machine.

Several Numerically Controlled (NC) machine tools have been and are currently in use at this Installation, mainly for production and maintenance support. A Bridgeport Vertical Milling Maching with three axis "Moog" is located at the Tool and Die Shop. This is a "point-to-point" machine which can be programmed by flexo-writer or an IBM S/360 ADAPT/AUTOSPOT, utilizing the disk operating system. Also in use is an American "Hustler" bar and chucking lathe equipped with an automatic, programmable bar feed and a GE 7540 Controller. Post-processors function with an IBM S/360 ADAPT disc operating system utilizing the Fortran IV language. Maintenance and production support is also received from a Burgmaster III, 25c, Econo-Center Mill/Drill Machine with GE Custom 7530 Controller. This is a three-axis, point-to-point machine with linear and circular interpolation in the x and y axes, equipped with an eight spindle programmable turret. An IBM 360 Computer using Fortran IV language is used for programming. Three Heald Model S borematic lathes are available for use at this Installation. Programmed by an IBM 360 Computer, these lathes are equipped with highly accurate Bendix Dynapath controls. Two of these lathes are currently in layaway and all were once used in production for turning hemispherical explosives.

2. Active and Planned Efforts

A Motorola M6800 Microprocessor System is presently being designed to monitor and control the Copperhead Warhead pouring process. In a manner somewhat similar to the TOW and Dragon processes, the microprocessor system will monitor and control time periods and temperatures on preheat, heating, cooling, and vibration cycles. During this process, a (remote) operator will communicate with the system via peripherals such as a cathode ray tube (CRT), data input keyboard and an output printer. This operator/system interaction will assure correct process operation and facilitate manual control of the process in case of an emergency.

Active and Planned Efforts (cont'd)

Partial funding for this system was received in FY78. Parts are presently being purchased on a system level and programming is being done on-site to assure familiarity with the software. It is intended that by using a person-processor interface the end product will be one of a standard quality.

The Line 4A Detonator Expansion Project will incorporate a central processor to supervise and control the operation of an entire facility from a single control room. It is planned that raw explosives be blended in the backline under the supervision of local controllers. After automatic dispensing, the powder is transferred to a series of detonator assembly machines in the front line. These machines will be interconnected to the central processor for data acquisition purposes. Rates of production, including accepted and rejected units will be readily available at the end of a shift for record purposes. Total funding for this project was received in FY78.

The planned Line 3A Expansion Project calls for an operation control system to eventually supervise all activities at this facility. The control system will be composed of three major subsystems: the process control system, management data system, and process surveillance system.

The process control system will include the programmable controllers (PC), operator's console, master control panel, process display, all sensors, input and output devices and remote equipment as required for the interface of input/output (I/O) devices in the process field.

The management data system will be interconnected to critical points in the process for supervision and data acquisition purposes.

The process surveillance subsystem will provide continuous monitoring of the process machinery and material handling equipment via remote closed circuit television cameras.

The three subsystems will be integrated within the overall operation control system and provisions will be made for anticipated expansion of the system to cover other manual operations. Additional reserve capabilities will be needed for an upcoming full modernization of Line 3A. The Project will be financially complete in FY84.

3. Projected CAM Needs

Based on the proven and anticipated success and benefits of funded CAM technological development activity, it is suggested that expanded CAM expenditures could be of benefit to this Installation in various areas. Computer control would be very desirable on the proposed electrical tester for MMT Projects RAAM, GEMSS and GATOR. Such control would also prove useful on future systems for automatically fluoroscoping items which require 100% radiographic inspections. A computer or microprocessor might also lend itself to application of a magnetic perturbator gage.

Future possible computer applications related to Plant engineering functions could include energy management, process and utilities monitoring and alarm and pollution alarms.

LAKE CITY ARMY AMMUNITION PLANT

1. CAM History

Computer Aided Manufacturing (CAM) is utilized in connection with the Small Caliber Ammunition Modernization Program (SCAMP) at Lake City Army Ammunition Plant (LCAAP). SCAMP was originated to provide a high speed completely integrated small caliber ammunition production facility. This production facility utilizes rotary type equipment and CAM operated presses to replace the World War II separately operated crank presses.

In 1975-76 Building 1 was refurbished by the Corps of Engineers to house the new generation production equipment which had been purchased by the Government in an effort to reduce the cost of manufacturing small arms ammunition.

The Case, Bullet, and Load & Assemble production submodules installed in the building were designed and fabricated by Gulf & Western of Swarthmore, PA. The basic machines consist of multiple rotary turrets connected by means of transport chains which convey the parts from one turret to the next. Each functional turret has 24 stations. These submodules are monitored and controlled by Digital Equipment Corporation's PDP 11/05 computer that utilizes Cassette Programming System (CAP-11) and Single User On-Line Program Development System (RT-11) Operating Systems. Major portions of the application programming are done in Assembly Language. The computer system controls and monitors the production and ejection of parts-in, parts-out, and ejects by tool stations, and displays this information on the video terminals.

Basically, the computer keeps track of all cases in the machine, records and stores data from the inspection devices, and rejects or unloads the cases, classifying them as determined by these inspections. In addition to the inspection function, the computers are used to generate the proper signals and apply them to the self-scan display, and to read the status input programmed by the operator on the control panel.

Performing 100-percent inspection of the product produced by the Case and Load & Assemble Submodules are the Cartridge Case Measurement Eject System (CCMES) and Cartridge Measurement Eject System (CMES) respectively. The CCMES is an automated system for inspection and rejection of cases produced at a rate of 1200 per minute. The system consists of a mechanical handler and measurement instruments, which are under the control of Data General Corporation's NOVA 210 computers. The measurement instruments are located at inspection stations spread throughout the path the cases follow through the mechanical handler. It operates under Real-Time Disk Operating System (RDOS). The software used are NOVA Assembly, FORTRAN and Extended BASIC. The Automated Material Handling System (AMHS) was designed to handle production components and materials transported on a first-in first-out basis,

between submodules via a Programmable Logic Controller (PLC) with manual backup controls in the event of a controller malfunction. Programmable Logic Controllers (PLC) are used to monitor and control component transfer, in-process storage and raw material supply for the five submodules.

The Management Information System (MIS - formerly PQCS) is a central data acquisition, data processing, control and communication system that is designed to coordinate data from the production submodules, inspection and material handling systems. If any of the product is unacceptable, MIS will direct the Automated Material Handling System to segregate the bad material from the normal production. Management reports will be provided as requested.

Inventory control information is maintained as well as production and reliability data. The system was designed and fabricated by Science Applications, Inc., Huntsville, Alabama, and is comprised of Digital Equipment Corporation's mini-computers with two PDP 11/34 serving as the host computers, six PDP 11/04 serving as pre-processors of data received from the production computers, two Disk Drives, one Line Printer, one Card Reader, one Mag Tape Drive, and several video terminals located throught the building. Software used to support this sytem are Multi-Tasking Process Control System (RSX-11M), DECNET Operating Systems and Multi-Processing Control Program (MCP).

The Ballistic Test Submodule is an integrated production test and data processing system capable of simultaneously testing different calibers of ammunition in several ranges. The data processing equipment consists of two Hewlett Packard 2100 computers, high speed printer/plotter, 9-track magnetic tapes and cathode ray tube terminal. The computer is programmed to handle up to ten different types of ammunition and fourteen ranges. Printouts from the system provide round by round data on all parameters tested as well as statistical information or groups of test rounds. Plots of accuracy dispersion and pressure/line curves can also be obtained on request. All test range data acquired is automatically recorded on magnetic tape for future recall. Range control is provided through specially designed units which link the range instrumentation, which consists of various sensors located on the test weapon and along the flight path for detection and measurement of various ballistic parameters, with the computer. These units are used for inputting all information needed to describe the tests to be performed and provide the means for remote firing of the weapon.

2. Active and Planned Efforts

The electronics and computer hardware on the Primer Insert Submodules are now nearly outdated and are not abreast with other systems in SCAMP. It has been recommended that the control system on these submodules be updated to make them more compatible with SCAMP equipment. Requests for proposals have been submitted to electronic firms to evaluate this area and make recommendations that would improve the system operation.

There are no recently completed efforts that were sponsored which contributed to CAM technology developments.

Active and Planned Efforts (cont'd)

Presently in process of procurement is a bullet and case off-line guage system. The systems will be capable of automatically inspecting 24 cartridge cases or bullets for several dimensional characteristics within five minutes. SAI will be providing a PDP 11/03 computer with each guage. These computers will also transmit the quality data to the Management Information System using a handshaking routine for further analysis and storage.

3. Projected CAM Needs

There are no additional (unfunded) CAM technology development efforts that are presently under consideration.

LONE STAR ARMY AMMUNITION PLANT

1. CAM History

The first Programmable Controller was installed at Lone Star Army Ammunition Plant in March, 1972. By end of FY 1979 there will be 21 Programmable Controllers and 2 Process Computers operational. These systems enhance the installation's production potential, its versatility, and its capabilities to produce safely. Five systems at this institution; the 105MM Downloading System, Initiating Explosives Process Control System, Materials Handling Control System, Process Computer Control System for the 105MM Melt Pour Facilities, and Programmable Controller Based Systems for the 483/509 Expansion Program include CAM applicants.

The Initiating Explosives Process Control System and Materials Handling Control System in particular represent a unique application of programmable controllers. Not only are I/O multiplexed, but the actual control logic is also multiplexed. Logic was also developed to allow downloading to the PLCs in the run mode. Maximum utilization of PLC memory was thus achieved.

o PROGRAMMABLE CONTROLLER BASED SYSTEMS FOR THE 483/509 EXPANSION PROGRAM

Two systems within the 483/509 modernization and expansion project at Lone Star Army Ammunition Plant are controlled by Programmable Controllers. Both are materials handling applications.

A Modicon Model 184 Programmable Controller with 118 wired I/O controls a grenade tray distribution system. The PC is supported by a Modicon Telephone Interface. Reliability has been excellent, while versitility has been somewhat limited by the absence of support hardware.

An Industrial Solid State Control's Model 1000 Programmable Controller with 240 wired I/O provides the controlling function for a powder feed system. An ISSC paper tape reader/punch and Model 590 CRT monitor loader provide the necessary backup.

Both systems were placed on line in June, 1976.

o MATERIAL HANDLING SYSTEM CONTROL SYSTEM

The Material Handling System Control System (MHSCS) is a safe and reliable material transportation system for the lead azide facility of the Lone Star Ammunition Plant. As such, the MHSCS moves carriers from a storage lane to process bays where the carriers are filled with powder. The filled carriers are then moved to a front line bay where the powder is used in the production of detonators. Emptied, the carriers are moved to a storage lane until again requested at a process bay.

The MHSCS performs these functions for thirteen process bays and forty-six front line bays -- all of which may generate requests simultaneously. The plant may also process several types of powder simultaneously and the MHSCS retains which front line bays and process bays are using a particular powder type. Also, the MHSCS retains the type of powder that is being carried by each carrier.

In addition to the control functions described above, the MHSCS provides several system status and history reports.

The MHSCS provides a means for the operator to initialize the system. This allows the control room operator to initialize the MHSCS data base to reflect the current system configuration (i.e., powder dedications, carrier locations, etc.). This initialization procedure is interactive and requires the operator to verify all inputs. When the initialization is complete, the system is placed in the normal run mode.

In order to provide a safe and reliable system which performs all of the functions described above, a hierarchical control system containing a ModComp II computer and three Allen-Bradley programmable logic controllers (PLCs) was created. Each of these components was then assigned the functions which it performs best.

The PLC keeps track of which system locations are occupied and provides traffic control interlock logic. All equipment manipulations (and direct communications with the operator consoles) are performed by the PLCs. Also, the PLC detects any unsafe conditions and halts the appropriate subsystems if necessary.

The central computer provides all services which require data base manipulations. The central computer provides system initialization and phasedown. All powder requests are serviced by the central computer. The central computer maintains carrier identification and provides carrier tracking. Also, the central computer provides the various status and historical reports for system analysis.

The data communications from the central computer to the PLC is accomplished by having the computer transmit control bits and words into a portion of the PLC data table. These control data are then used by the PLC control logic to perform the requested function.

MATERIAL HANDLING SYSTEM CONTROL SYSTEM (cont'd)

Operator requests to the MHS are entered one of two ways. The control room operator enters requests for system initialization, status reports and some control functions from the control room terminal. All other requests are entered by pushbuttons located at the front line bays, the cleaning bays, and in the control room.

The 105MM Download System was developed to automatically and remotely render rounds safe and recoup the loaded projectiles.

A remotely operable forklift in conjunction with a head aimed television system unstacks and relocates palletized rounds to the depalletizer station. Control of forklift function is implemented with a multiplexed, 23 channel analog data path thru a special umbilical cable which links the forklift to a remote control trailer.

At the depalletizer station saws using friction cutting blades sever the pallet's banding straps. Individual boxes are then placed on a conveyor gate which releases them to the Delid Station. The boxes enter the Renovation Building individually where the projectiles are defuzed.

Automatic functioning of the 105MM Downloading System was originaly controlled by an Industrial Solid State Control's IPC 300 programmable controller w/8K memory and 145 wired I/O. The unit was supported by ISSC's Model 590 CRT Monitor/Loader and Paper Tape Reader/Punch. This configuration did not provide the reliability or maintainability required by the operation.

In July, 1978 the wire wrap processor chassis was replaced by an upgraded printed circuit board type chassis. The CRT was upgraded to a Model 395 and the Paper Tape Reader/Punch replaced by a Magnetic Tape Cassette Unit. The system has since performed in a satisfactory manner.

2. Active and Planned Efforts

o INITIATING EXPLOSIVES PROCESS CONTROL SYSTEM

The modernization and automation of detonator production facilites at Lone Star Army Ammunition Plant is a multi-phased effort.

In the current phase of modernization, bulk powder processing is being automated and a materials handling system installed to carry processed explosives from the new processing equipment to detonator production areas. The processing equipment and its associated Process Control System are described below. A description of the Materials Handling System Control System is described elsewhere.

The process systems are clusters of barricades used to dry, blend, and dispense initiating explosives.

Machine sequencing is controlled by Allen Bradley PLC programmable controllers. Two processors with 8K memeory and 396 I/O each control the Drying Systems while 2 processor with 8K memory and 510 I/O each control 6 Primer Mix Systems. A fifth processor with 4K memory and 340 I/O controls the seventh Primer Mix System and interfaces to front line storage barricades.

INITIATING EXPLOSIVES PROCESS CONTROL SYSTEM (cont'd)

System monitoring and control room operator I/O tasks are handled thru an ADDS CRT terminal. The controllers also interface to a Process Air Control System made by Foxboro and a Weighing System provided by BLH Electronics. The systems were installed and checked out with little difficulty.

o PROCESS CONTROL COMPUTER SYSTEM f/105MM MELT POUR FACILITIES

The E-Line production facility at Lone Star Army Ammunition Plant is being modernized including the addition of new buildings and equipment along with refurbishing of currently existing buildings to meet Army's specified 105MM Load-Assemble-Pack production requirements.

The Process Control System required to control the load operations of E-Line production facilities is designed to bring some of the operations under computer control, and to introduce other efficiencies to the process. The system is configured as a central control satellite node system. Local process control responsibilities are assigned to the satellite controllers which are Allen Bradley PLC programmable controllers. A Taylor Model 1010/73 computer with associated peripheral devices integrates the total production line and exercises control over the satellites in a supervisory control mode. The Model 1010/73 consists of two Varian V72 computers connected through a bus switch and programmed such that on primary system failure, control is switched to the secondary computer.

The Improved Commercial Conveyor System is the mechanism for moving the projectiles, which are to be filled, around and through the facility. This system transports the projectiles in a 4 by 4 array resulting in each carrier containing 16 projectiles or less. The control system will track each carrier through the facility and remember all pertinent information connected with it to allow complete identification and quality control actions.

Control of the ICC system will be implemented through the Programmable Controllers. This is accomplished by the computer system changing the data field in the programmable controllers memory to cause the desired logic decision to be made. Thus, the programmable controllers will provide all local control as well as serving as the end control points for the central operator through the computer system.

The X-Ray System is operated by a PLC under Supervisory control. This system serves the function of performing quality control and as such, can perform in either the screening or sampling modes usually associated with QA requirements. ICC Carriers filled with 16 projectiles are positioned at unload transfer stations for transfer to a carrousel conveyor. The projectiles are placed four at a time onto pallets of the carrousel. A film cassette is placed behind them and the pallet is conveyed through the x-ray cell for exposure.

After being unloaded, the ICC carriers are moved to the reload transfer station to receive the x-rayed projectiles. The cassettes are then transported to film handlers where they are processed.

As the carriers enter the stop stations where projectile data is added, the data block associated with each carrier will be expanded in memory to accomodate this additional information.

To check the ICC tracking the computer will accept BCD inputs from six Bar Code Readers. These signals will be compared to the number that the computer has stored in its computer registers. If there is an error, an alarm condition will prevail and the carriers will be stopped via the PLC's.

By tracking carrier and pallets in software, the operator, via the CRT, can change data, select sampling rates and recall any inforamtion previously entered for any projectile, carrier, or pallet. The operator can cause carriers to be by-passed and choose sampling rates.

Sensors and interface circuitry will be constantly checked by the control computer for electrical integrity. In the event the expected response is not received, the interface is assumed faulty. In this case, a warning will be flashed on the CRT and a message logged on the teleprinter.

Backup control is provided by a duplicate computer. The primary computer continually runs resident diagnostics on both the main fram and the I/O. In the event that the computer fails any of these diagnostics, switch over to the secondary computer is automatic. Essentially, the system will continue to operate exactly as it had been on the primary computer.

The Programmable Controller Interface will be a standard EIA-RS-232-C interface. They will operate in a half-duplex mode with a nominal rate of 4800 band. Sequentially redundancy check characters for error detection will be generated.

The computer software will incorporate routines which allow for modification of Programmable Controller programs, storage of programs on the disc and printout of the stored programs. In addition, the capability to change counts and certain other parameters of the PLC's is provided through the CRT. These areas are described in block operation descriptions. PLC program manipulation will be done in the background programs only.

The system proposed utilizes as much as practical a standard software package available from Taylor. Where standard packages are not available applications programs are being written.

The Taylor 1010/73 Dual Computer System with its 224 analog inputs, 192 analog output, 112 digital inputs, and 192 digital outputs is supported by two General Electric RO 1200 terminates, an LA-36 DEC writer, varian 70-7102 magnetic tape, two color CRTS, a varian 70-6721 line printer, a varian 70-6200 card reader, and six each 1.2 megaword moving head disc units.

Satellite Control is accomplished by ten Allen Bradley PLCs, each with a computer interface. These PLCs control 34 different machines and operations with 4500 I/O.

The facility is being modernized to produce 15,000 finished projectiles per day at a rate of 48 projectiles/minute.

3. Projected CAM Needs No reply.

LOUISIANA ARMY AMMUNITION PLANT

1. CAM History

Louisiana Army Ammunition Plant installed its first Numerical Control Machine Tool in 1972. The first Numerical Control Machine Tools were LeBlond. Tape Turn Lathes, equipped with G. E. Mark Century Controls, 7500. These two (2) lathes were procured to machine press toolings and other machine spares.

During the same year, four (4) new Press Systems, each consisting of three (3) presses, and two (2) Manipulators/Robots were procured. The Press Systems were equipped with G. E. Logitrol Controls. This was a significant improvement over the old system.

A Co-ordinate Measuring Systems was procured during the same time period. This system came equipped with PDP Mini-Computer. This system was installed in the Metrology Laboratory of the Metal Parts Manufacturing Line. The availability of this system provided the Quality Control personnel an added capability in the area of gaging by way of reducing time and gaging intricate components with ease.

Robotics

Louisiana Army Ammunition Plant (LAAP) has also procured Industrial Robots for handling 155MM M483A1 and M107 metal parts. LAAP currently employs:

- o Eight (8) Manipulators in the press area, Control G. E. Logitrol.
- o Two (2) API Robots in the M107 nosing areas.
- o Two (2) AMF Versatron Robots in the slot and deburr operation, M483A1.
- o Two (2) AMF Versatron Robots in machine ogive operation, M483A1.

O. R. Techniques

Louisiana Army Ammunition Plant has also utilized a few operations research (O. R.) techniques as an aid in the areas of Production Planning, Project Management and Industrial Engineering. Computer simulation using GPSS was used to model the L/A/P operations of 155MM M107 projectiles, and also the metal parts manufacturing of the same projectile. LAAP is convinced of the potential of O. R. techniques in the area of manufacturing, but their use in the plant has been limited due to the non-availability of a computer system that could handle these models.

2. Active and Planned Efforts

Numerical Control

Louisiana Army Ammunition Plant is currently installing the following N/C machines:

Numerical Control (cont'd)

- Olofsson Three Spindle Lathes - These lathes, (2 each) are equipped with Allen Bradley Controls, Catalog No. 7360, specifically designed to machine the aluminum base of 155MM M483A1 projectile.

- J & L Lathes - These machines, (5 each) are designed to machine the aluminum ogive of the 155MM M483A1 projectile. They are equipped with Allen Bradley Controls, Catalog No. 7360.

  The Allen Bradley System 7360 is a Computerized Numerical Control (CNC) and consists of an industrial processor, a CRT and MDI keyboard, control panels, one tape reader, I/O racks, and power supplies.

- Seneca Falls Threading Machine - These machines, (4 each) machine the threads; both ogive and base ends in the body of 155MM M483A1 projectile. They are designed with Reliance Automate, (Part No. 00143-5RA) Programmable Controller.

Programmable Controller

In addition to the above mentioned N/C machines, Louisiana Army Ammunition Plant is also installing the following systems employing Programmable Controllers:

- Band Welders: The band welders, (Taylor Winfield) are designed with Modicon Programmable Controllers. These controllers can be re-programmed by a programming panel which uses ultra-violet light. These machines are used in the manufacturing of 155MM M483A1 projectile metal parts.

- Finish Turn Lathes, 155MM M483A1 Projectile Metal Parts: These machines employ Allen Bradley PLC-2 Controllers in place of conventional relay logic. The controllers can be re-programmed to reflect changes in the machining variables.

- Hard Coat Anodize and Chromate Systems, 155MM M483A1: These systems are equipped with Texas Instrument's Programmable Controllers, Model 5T1 sequencer. They can be re-programmed to change the anodizing and chromating process variables.

- Material Handling System: The Material Handling System for the metal parts manufacturing facility at Louisiana Army Ammunition Plant is being equipped with Allen Bradley PLC-2 Controllers. These controllers can be re-programmed whenever necessary.

Louisiana Army Ammunition Plant is considering the development of a Manufacturing Data Collection and Analysis Systems in the metal parts manufacturing line.

The system will consist of a Central Mini-Computer interfaced with all pieces of production equipment through input/output devices.

Programmable Controller (cont'd)

The system will provide manufacturing data (e.g. no. of units produced, down time, rejects, labor, etc.) on real time basis. The system will also perform statistical calculations, and compile learning/improvement, curve data.

The system will be designed with capability to interface with an overall Management Information System that LAAP might develop in the future. It is envisioned that this system will provide all the necessary data of the Management Information System.

3. Projected CAM Needs

Additional CAM technology development system that would benefit Louisiana Army Ammunition Plant, but are yet unfunded include the following:

- Computer Aided Design Drafting (CADD) - This system will be used for drafting and developing layout of facilities. Computer aided drafting reduces drafting time, and can be programmed to compute moment of inertia, centroid, etc., of the part during the same time. The system that is envisioned will be interactive and possible 3D.

- Rapid Data Collection (RADC) - This system is a high speed computer application of the third level MTM using DATAMYTE input device, a mini-computer, and a printer. It is felt that the same system can be used for line balancing.

- Energy Management System - This system will maintain the energy requirement and help schedule the operation of power consuming equipment in such a way that they don't operate at peak demand periods so as to reduce power demand charges. It has been claimed that a typical Energy Management System saves 11 to 22% in electrical utility.

- Inventory and Maintenance System - A new inventory system would interface with production and receiving and would provide real time information. The maintenance system would incorporate programs for preventive maintenance and spares provisioning which would require that it be interfaced with the inventory system. These two (2) systems would be sub-systems to the LAAP's overall Management Information System.

- Direct Numerical Control (DNC) - It is envisioned that the technology of DNC will immensely help LAAP in the years to come. DNC is a relatively new development that refers to the automatic operation of a machine from instruction fed directly from the computer. In other words, there is no tape. Instead of the computer's preparing instruction and then punching a tape, the instructions are transmitted from the computer directly to the drive motors of the machine tools, and since the computer can be reprogrammed on a time share basis, it is possible to operate more than one machine tool from the same computer at the same time.

RADFORD ARMY AMMUNITION PLANT

1. CAM History

Radford AAP began installation of a totally automated facility for the continuous manufacture of single-based propellant in 1971. This system utilizes two Digital Equipment Corporation PDP8 computers interconnected to form a configuration termed "PDP-88" system. In this configuration, one computer maintains responsibility for direct digital control (DDC) of a line and the other computer serves a supervisory function, ready to take over control of the line should the DDC computer fail.

Additional functions needed to support this line include periodic sampling of the product for continuous quality control. These samples will undergo analysis in a computerized gas chromatograph system which will analyze the content of the sample to determine suitability of the manufactured propellant. Work on the line and on the computer programs was scheduled for completion in mid-1979, with testing of the line scheduled during late 1979.

2. Active and Planned Efforts

Radford AAP is currently rebuilding a facility for the continuous manufacture of TNT. This line will be equipped with Foxboro Videospec analog equipment, which will be used to control cooling water flow and ingredient feed rates. The addition of a currently unfunded supervisory control computer is being considered to adjust acid feed streams for upstream flow changes. This computer will provide a faster approach to balanced flow, the result being a more stable overall control.

Radford AAP is presently capturing range firing data on magnetic tape for approximately 50 percent of all rockets tested. These include the LAW, SIDETHRUSTER, TOW IGNITER, and TOW LAUNCH rockets. This data is captured by a high-speed data acquisition device and sent to the Univac-Spectra 70/45 computer for analysis. This completes the first phase of a two-phase project to automate the ballistics range. Phase II of this project will involve a new control facility, replacing marginal equipment with new, more reliable and accurate devices. Among these will be a high-speed data acquisition device coupled directly to a local micro-computer capable of all required data reduction.

Radford AAP is currently designing an automated process control system for the continuous manufacture of multi-base propellant. The present design includes four Fox 1A computers, each with a Videospec analog control backup, and one Fox 3 computer. The Fox 1A computers will provide supervisory setpoint information to Universal Input/Output devices located at each manufacturing building. The Universal Input devices are responsible for the actual digital control of the line, based upon setpoints provided by the Fox 1A computers.

The Fox 3 computer will be responsible for acid tank farms material management, insuring that the correct ingredients and volumes are pumped to the manufacturing buildings.

3. Projected CAM Needs

No reply.

RIVERBANK ARMY AMMUNITION PLANT

1. CAM History

Riverbank Army Ammunition Plant installed its first and only NC machine tool in 1973. The NC lathe basically is utilized to manufacture tooling for the 81MM and 60MM Projectiles and is programmed manually.

The Operating Contractor currently leases a terminal which ties into a computer at another corporate division. The use of the terminal is to handle payroll functions.

An Automatic Data Processing Equipment (ADPE) Survey was scheduled in 1978. The purpose of the survey was to identify additional areas of ADP application and to determine equipment requirements. The areas identified for ADP application are:

a. The Operating Contractor's accounting system.

b. Material control and inventory.

c. Maintenance scheduling, inspections, and lubrication.

d. Production and shipping schedules.

e. Engineering project schedules, economic analyses and programs.

f. Quality Assurance reports and gage calibration/inventory lists.

g. Utilities usage and energy conservation analyses/reports.

Details of the results of the survey will be available.

2. Active and Planned Efforts No reply.

3. Projected CAM Needs No reply.

SCRANTON ARMY AMMUNITION PLANT

1. CAM History

The operating contractor at Scranton Army Ammunition Plant (SAAP), Chamberlain Manufacturing Corporation, was awarded a contract to install a manufacturing line to produce the metal parts for the M509 projectile. This is a three piece shell with aluminum base and ogive and a steel body. During the manufacturing feasibility phase, the operating contractor determined that numerically controlled machinery would be advantageous. The decision to use a numerically controlled lathe was based on the economic savings. The NC lathes perform more rapidly than manual turret lathes and there is an anticipated lower scrap rate.

CAM History (cont'd)

The operating contractor purchased 7 shaft lathes and 3 combination lathes from Jones and Lamson Manufacturing Co. The shaft lathes are used on the steel body of the diameter and to cut the threads. The combination lathes are used on the aluminum ogive to finish machine the outside diameter, bore two inner diameters and to thread the part. In addition, the operating contractor purchased equipment to manufacture and edit the tapes. The lathes purchased are actually CNC (Computer Numerically Controlled) machines. This allows the operator to make instant program corrections and to modify the tapes or to operate manually without tapes.

Another computer system used is a computer controlled welding system. This system is a fully automatic welding system which uses the gas steel military projectiles, non-ferrous overlays which are subsequently machined into rotating bands. A micro-processor is used in operating and monitoring the system. The banding is accomplished by rotating the projectile in a fixture beneath the welding head during metal deposition.

Control of arc length during deposition is one of the chief factors in achieving uniformly acceptable quality in rotating bands. Changes in arc length cause variations in intergranular penetration of the overlay material into the base metal, weld spatter, pitting, etc. Arc length must be maintained within 1/16 inch of the pre-set value to insure optimum control of intergranular penetration and weld spatter. Optical devices and TV cameras have previously been adapted to controlling arc length. The present TV camera provides information to the computer to control arc length.

2. Active and Planned Efforts

The operating contractor is presently installing 3 heat treat furnace systems. These systems consist of six furnaces (three heat, quench, and draw lines). The shell projectiles will be automatically loaded from loader/unloader machines into baskets. These baskets are then automatically transported by a cart (on tracks) to the particular furnace and the basket then starts the processing through the furnaces and quenching operation. After cooling, the basket is transported by the cart and unloaded automatically. Ten (10) programmable controllers (computers) are used in connection with this operation. Three are used to monitor the processing of the baskets (tracking and controlling the location), three are used to monitor the furnaces (temperature controlling and combustion efficiency), three are used to control each conveyor loader/unloader and one is used to control the cart. The advantages of programmable controllers over conventional relay/switch controls are the ease of process changes, cost and room. The process can be altered by changing the program through a keyboard as opposed to changing wiring. It is less expensive to purchase the computers than the many relays, switches and cabinets required in an electric control system and the computers take less space than the cabinetry that would be associated with electric controls. The operating contractor elected to use ten computers rather than one large computer to increase system reliability; i.e., if one fails the others can be used. The computers use less energy than an electric system. In addition, the

Active and Planned Efforts (cont'd)

manufacturer offers a diagnostic service which lessens troubleshooting time in the event of system/computer breakdown.

3. Projected CAM Needs

SAAP is not sponsoring any efforts contributing to CAM technology.

The additional CAM technology that would assist SAAP would be the publication of a manual listing all types of NC machinery and their options. For instance, the operating contractor was unaware of a hi-lo pressure switch option. This option allows different chucking pressures to be used. When an aluminum part or a steel tube is clamped, higher pressures are normally used for the rough cut and lower clamping pressures for a finish cut. If there is only one pressure, the parts have a tendency to spring out and go out of tolerance after the finish cut. A hi-lo switch allows machine control of this function. If a listing were published, then selectors of machinery would be more aware of worthwhile options and types of equipment.

In-Active Army Ammunition Plants

BADGER ARMY AMMUNITION PLANT

1. CAM History

In 1971 Badger Army Ammunition Plant (BAAP) installed a Honeywell 316 computer in the Ballistics Test Laboratory. The computer was used for real time data collection and reduction of small arms velocity tests and for closed bomb testing of cannon propellant. Just prior to shutdown of production, the computer was being programmed to handle data collection and computations for rocket testing. Barrel histories, laboratory inventories, and historical data files were a few of its other applications. The results of these computer applications were faster test turnaround and reduced manpower requirements.

2. Active and Planned Efforts

Badger will install a pilot scale continuous line for BALL POWDER manufacture. This continuous line will have a Rosemount control system which contains a dedicated computer. It will control the continuous line and provide data for evaluation of the pilot scale system.

The modernization of BAAP's smokeless propellant production facilities is presently scheduled to begin in the FY83 time frame. The Project, No. 5773046-5B, Development Brochure and Equipment Functional Criteria have been completed. Additional funding has been requested for the completion of the control system criteria specifications.

Active and Planned Efforts (cont'd)

Under this proposal, the solvent recovery, water dry and packout operations will be controlled by local auto or manual modes with the ingredient feed, green propellant manufacture and air dry operations under computer control. The computerized system will, in addition to controlling the above processes, monitor the local auto and manual operations for alarm conditions, provide process inventory control (i.e., raw material input, utility usage and production efficiency data) and provide software for process optimization. The following is a brief description of the proposed CAM system.

Control Room - The control room/buildings will contain the operator displays, operator and engineers control console, process alarm and graphic console disc, teletypes, line printer and two control process units. One computer will maintain control, while the other acts as monitor and diagnostic. Both computers will have interchangeable access to process data and in case of a computer failure, the second unit can assume control of the process.

Interface Rooms - The devices to interface the process sensors and controls are located in the interface rooms. In addition to the interface devices, there will be a number of micro computers which will be utilized to perform the control function as directed by the CPU. These units will also provide a stand alone capability in the event both control computers fail.

Field Wiring - Digital communication between the control room and the interface bays will be accomplished via a redundant serial data highway which will provide loop collapse and control unit bypass. Utilizing the above techniques and barring a major power source outage, the control system should be capable of bringing the automated portion of the process to an orderly shutdown under most feasible conditions.

3. Projected CAM Needs

The following CAM effort would benefit BAAP but has not been formally proposed. A system of remote input terminal located in the operating area and connected to the existing ADP system - those remote terminals and the required associated software would be used for spare parts, raw materials and finished product inventory and control. Terminals located in the maintenance shop area and/or line offices would also be used to input RAM data which would facilitate the accumulation of historical information. This, in turn, would be used to increase the effectiveness of the existing maintenance programs and to establish the RAM requirement for the Production Base Modernization Program.

JOLIET ARMY AMMUNITION PLANT

1. CAM History

The traditional batch process for manufacture of TNT was used at the Joliet Army Ammunition Plant (JAAP) for production of TNT during World War II, Korea and Essentially all of the SEA conflict. In 1970 a project was approved for replacement of three batch lines with continuous lines utilizing the CIL process. One continuous line was placed in operation in 1975 and continued in operation until 1976. In 1972 a project was approved for replacement of

three additional batch TNT lines with continuous lines using the same process but employing computer control (DDC). This was a true CAM system based on "state of the art" in 1972.

The computer system, designated the PCP-88 System, was provided by the Foxboro Company. The PCP-88 System is a digital computer control system designed to fulfill the requirement for startup, shutdown, control, and with facility for optimization of the continuous TNT lines to be installed at the JAAP installation. The modular concept of both equipment (hardware) and computer programming (software) that has been incorporated in the JAAP PCP-88 System enables the maximum use to be made of field-proven equipment and software, while still providing for all the special requirements involved in operating a TNT manufacturing complex.

The JAAP system is composed of two digital computer systems. Each system will be applied to 6 TNT lines and includes the following equipment and software subsystems:

- o DDC Computer Subsystem and Software
- o Main Data Bus Subsystem
- o Supervisory Computer Subsystem and Software
- o Auxiliary Data Bus Subsystem

The programming system consists of proven standard software. The DDC program subsystem is a core-drum configuration that provides control of the input/output functions and sequential operations. The supervisory program subsystem provides access to processing data and additional computational and data processing capacity, and it automatically assumes control of functions in the event of failure of the DDC computer subsystem.

While computer hardware has the capability for startup, shutdown, control, and optimization, software presently is limited to the control function only. Approval and funding was obtained for a live prove-out of one computer controlled continuous TNT line, on 22 June 1977, which successfully met the established criteria. This test evaluated the control function only. Production operations continued until 25 July 1977. A total of 6,080,000 lbs. of TNT were produced with a reject rate of 2.26%. All reject material was processed through the line and at the conclusion of operations no reject TNT remained on hand. The line operated smoothly and successfully at a 55 ton per day rate during this final phase.

2. Active and Planned Efforts

The computer provided for the three lines has a six-line capability. Procurement of additional line panels and the necessary modifications required to provide DDC operation of Lines 13, 14, and 15 is desirable. This type of operation is inherently safe due to the multiplicity of back-up features in the controlling parameters. In addition, multi-line computer controlled

Active and Planned Efforts (cont'd)

operations could result in personnel reductions due to the joint usage of maintenance personnel and production personnel. The DDC line operated more smoothly and with better control and uniformity than did a manually-operated line. Because of the ability to finely tune line operations, it is believed that a reduction in raw material usage and a more consistent quality of product would result.

Extensive use of CAM technology poses a unique problem for ammunition plants. The active-inactive cycle which is imposed by the very nature of their mission, means that these sophisticated systems must be capable of being maintained in a proper readiness posture during extended periods of idleness (layaway). Since no one has ever laid away a computer, there was no precedent which could be followed when layaway became necessary at the Joliet AAP. In order to obtain information which would be applicable for all CAM systems, a test program was initiated at this location to actually evaluate the effect of a layaway shutdown on a computer system. An ARRADCOM project was approved and funded for these tests. In October, 1976 the computer received a complete check. Then power was shut off and the system left dormant in a controlled environment (temperature and humidity). After six months (April, 1977) of dormancy, the computer was powered up and a complete series of diagnostic tests run to determine if any deterioration had occurred and to locate failed components. No deleterious effects were detected. The test was repeated after another six-month interval (October, 1977) and again no deterioration was observed. Tests will be repeated at six-month intervals Results thus far indicate that layaway of a computer under controlled atmospheres is completely feasible.

3. Projected CAM Needs

Software (batch logic) must be developed to permit computerized startup and shutdown of a line.

The full potential of the computer cannot be realized until continuous, in-line process analyzers are available. Some effort has been made in this direction, utilizing chromatography, but without positive results. This is an area which should be pursued vigorously by ARRADCOM.

RAVENNA ARMY AMMUNITION PLANT

1. CAM History

No CAM facilities installed.

2. Active and Planned Efforts

No CAM efforts are currently active or planned.

3. Projected CAM Needs

Many opportunities exist for the application of CAM at Ravenna AAP. LAP Lines 2, 3 and 4, which are equipped for the items to be produced under mobilization, are in an inactive status. A study should be funded at the earliest opportunity to identify and evaluate potential applications of CAM.

The balance of the lines which are on the mobilization schedule (LAP Lines 1, 9, 10, and 11) have greater potential for application of CAM since no equipment exists for the lines. All opportunities for application of CAM would be evaluated during preliminary engineering for these lines. To date, preliminary engineering has not been funded.

SUNFLOWER ARMY AMMUNITION PLANT

1. CAM History

At the present time there are no active computers or programmable controllers in use at Sunflower Army Ammunition Plant (SFAAP). However, there are seven programmable controllers that have been purchased and have been or will be installed under Modernization Projects but have not been put into service as of this date.

The Mechanized Roll complexes utilize four programmable controllers, one in each of four process lines. These programmable controllers were purchased in 1972, from Reliance Electric Company and are their Automate 33's.

One Automate 33 controls one automated roll line from past batch weighing through carpet roll winding including the operation of fire doors, conveyors, and calenders.

One process line is scheduled for prove-out in 1980, while the other three process lines are scheduled for layaway.

One of the seven programmable controllers will be used to control the operation of the centrifuges in the Nitroguanidine 45 ton/day plant and one will be used to control the centrifuge in the Nitroguanidine Support Equipment plant. Both plants are presently under construction. Both controllers are Industrial Solid State Controls Incorporated Model IPC-300. One controller was purchased in 1975 and the other in 1978.

Each controller will control the centrifuges automatic cycle of feeding a slurry, wringing at high speed, wash down, and unloading. These two plants are scheduled for prove-out through 1980.

The seventh programmable controller has been purchased by the Corps of Engineers for installation in a new Calcium Cyanamide Plant that is presently under construction at SFAAP. This controller will control the entire calcium cyanamide process from raw material input to finished product.

Some of major equipment controlled and interlocked would be elevators, feeders, conveyors, rotary kiln, and rotary cooler.

The programmable controller which was purchased in 1978, is an Allen Bradley Model 1774PCL and is scheduled to be utilized during Calcium Cyanamide Plant prove-out through 1980.

2. Active and Planned Efforts

In FY 1985, a computer is scheduled for procurement and installation under the Continuous Automated Multi-Base Line expansion project at SFAAP. This computer will utilize variable input information to control various process functions primarily in the Green Line area.

3. Projected CAM Needs No reply.

TWIN CITIES ARMY AMMUNITION PLANT

1. CAM History

Computer Aided Manufacturing (CAM) developments at Twin Cities AAP occured in three general areas:

a. Acquisition and installation of 8 NC Machines for tool manufactuirng and general machine shop use.

b. Installation and operation of the prototype Small Caliber Ammunition Modernization Program (SCAMP) Module A1 which used computer control for small caliber ammunition (5.56mm) manufacture and test.

c. Automotion of the spare parts and general tool inventory procurement control system using the installtion general purpose Honeywell 120 computer system.

This narrative will not discuss 155mm M107 Metal Parts production which had no NC operations and Honeywell Inc. which has extensive NC operations, but is a tenant reportable to DCASO and only receives utility support from this office.

o MACHINE SHOP MODERNIZATION - NC MACHINES.

The acquisition of the eight NC machine tools was initiated by a PEQUA study done for APSA in January 1967. Procurement was part of that done under AMC Project 56885219 which totalled approximately $2,000,000 to establish an in-house tooling capability. Although the equipment was installed, programs generated and operated, the tool making operation was reduced in late 1969 and early 1970, when extensive off-site commercial capability became available to produce tools at less cost than in-house operations. The whole facility was laid away with the shut down of conventional ammunition small caliber manufacturing facilities in September 1973.

NC Equipment on Hand

Quantity	Model	Manufacturer	Description
1	JOS13	P&W Machine Tool Div - Colt Industries	Boring Machine, Jig, Vertical
1	C	P&W Machine Tool Div - Colt Industries	Drilling Machine, Upright Single Spindle, Floor Type Positioning.

Quantity	Model	Manufacturer	Description
1	SP24	Cleerman Machine Tool	Boring - Drilling - Milling Machine - Vertical Table Type.
3	CINTIMATIC	Cin. Milacron, Inc.	Boring - Drilling - Milling Machine - Vertical Table Type.
2	32 PN	Fosdick Machine Tool Co.	Boring Machine, Jig, Vertical.

o SMALL CALIBER AMMUNITION MODERNIZATION PROGRAM (SCAMP)

The Small Caliber Ammunition Modernization Program (SCAMP) began with a series of concept and feasibility studies in 1967. These studies for the Module A system (calibers up to but not including 50 caliber) were intended to bring small caliber ammunition production up to the current state of the art for metal working equipment. The final prototype consisted of a production line or module producing at ten times the conventional rate made up of a series of submodules which manufactured a component or performed a major functional operation. The manufacturing submodules were a series of 24 tool station turret presses with transfer mechanisms between them to transfer the work piece from one operation to the next.

Inspection and ballistic test operations were also automated. Submodules and control/monitoring systems are tabulated below:

Submodule	Manufacturer	Function	Computer
Case Manufacture	Gulf and Western	Manufacture Cartridge Cases from brass cups	a. Hand wired relay systems for monitoring and control b. PDP-8 for off-line gage dimension data.
Case Inspection	Battelle NW	Inspect completed cartridge cases for dimensions and flaws.	NOVA 800 monitoring control and data collection computer.
Bullet Manufacture	Gulf & Western	Ball Bullet Manufacture	a. PDP-11 for monitoring and control. b. PDP-8 for off-line gage dimension data.
Primer Insert	FMC Corp.	Insert trimers in cases from G&W machine.	Honeywell 316 for monitoring and control.

Submodule	Manufacturer	Function	Computer
Load/Assemble	Perry Industries	Assemble bullets and cases from previous submodules with metered powder into cartridges.	Honeywell 316 for monitoring and control.
Ballistic Test	AAI	Collect data from ballistic firing and analyze	Hewett Packard 100
Production Quality Control System	Honeywell Inc.	Monitor and control of entire duction module	Expanded Honeywell 316 System

The submodules, individually and together as a system, were operated in a series of preproduction tests from January 1974 thru April 1976 producing over 50,000,000 rounds of 5.56mm ammunition. Lessons learned and improvements developed were incorporated into the five follow-on modules installed and tested at Lake City AAP from June 1975 to the present under Project 5XX2396.

o TOOL AND SPARE PARTS CONTROL.

During the later phases of operations and production, the SCAMP identification numbers, quantity on hand and on order, and items below minimum quantity were generated weekly by computer print-out from the Honeywell 120 system. The system was good for procurement purposes and inventory control, but could not furnish - except in a general way - tool and spare part mortality data. The software and current inventory print-out is currently available and could be used in the event of start-up.

2. Active and Planned Efforts

SCAMP Program. As a minimum, replacement of equipment on loan to Lake City AAP would be necessary to make the production line operational. Since the Honeywell 316 and other CAM systems used are obsolete and would be difficult to maintain, replacement by minicomputer or programmable logic controller would be desirable. Retrofit of the primary production equipment to make it compatible with that at Lake City AAP is tentatively scheduled for the mid 1990's. Utilization of automatic test equipment data in lieu of that generated by slow mechanical devices and by hand for QA and acceptance tests would be a very desirable and cost effective feature.

3. Projected CAM Needs

Machine Shop - NC Machines. An extensive program to generate tapes and software to produce a majority of tools required for the conventional production process is necessary to obtain maximum and cost-effective utilization of these machines.

Submodule	Manufacturer	Function	Computer
Load/Assemble	Perry Industries	Assemble bullets and cases from previous submodules with metered powder into cartridges.	Honeywell 316 for monitoring and control.
Ballistic Test	AAI	Collect data from ballistic firing and analyze	Hewett Packard 100
Production Quality Control System	Honeywell Inc.	Monitor and control of entire duction module	Expanded Honeywell 316 System

The submodules, individually and together as a system, were operated in a series of preproduction tests from January 1974 thru April 1976 producing over 50,000,000 rounds of 5.56mm ammunition. Lessons learned and improvements developed were incorporated into the five follow-on modules installed and tested at Lake City AAP from June 1975 to the present under Project 5XX2396.

o TOOL AND SPARE PARTS CONTROL.

During the later phases of operations and production, the SCAMP identification numbers, quantity on hand and on order, and items below minimum quantity were generated weekly by computer print-out from the Honeywell 120 system. The system was good for procurement purposes and inventory control, but could not furnish - except in a general way - tool and spare part mortality data. The software and current inventory print-out is currently available and could be used in the event of start-up.

2. Active and Planned Efforts

SCAMP Program. As a minimum, replacement of equipment on loan to Lake City AAP would be necessary to make the production line operational. Since the Honeywell 316 and other CAM systems used are obsolete and would be difficult to maintain, replacement by minicomputer or programmable logic controller would be desirable. Retrofit of the primary production equipment to make it compatible with that at Lake City AAP is tentatively scheduled for the mid 1990's. Utilization of automatic test equipment data in lieu of that generated by slow mechanical devices and by hand for QA and acceptance tests would be a very desirable and cost effective feature.

3. Projected CAM Needs

Machine Shop - NC Machines. An extensive program to generate tapes and software to produce a majority of tools required for the conventional production process is necessary to obtain maximum and cost-effective utilization of these machines.

Tool and Spare Parts Control. Modification of the existing programs on generation of a new one which would generate tool mortality and effectiveness data would be very desirable. Automated generation of cost and cost effectiveness at the major points in the production process would also be desirable.

VOLUNTEER ARMY AMMUNITION PLANT

1. CAM History

During the mid 1960's the United States Army made a decision to begin modernization of the old World War I vintage batch TNT lines. The modernization work involved replacing the old facilities with a new process. The new process was of the continuous nitration type. It was designed by Canadian Industries Limited (CIL). The first CIL lines to be built in the United States were at Radford Army Ammunition Plant (RAAP) in Virginia. Three 50 ton per day lines were constructed utilizing limited automatic analog control. These lines were operated by employees located inside the process buildings. Eight more lines of the same design were built; five at Newport Army Ammunition Plant (NAAP), and three at Joliet Army Ammunition Plant (JAAP).

Three lines were then scheduled to be built (FY70) at the Volunteer Army Ammunition Plant (VAAP) utilizing the same method of control. However, after a feasibility study had been made in January 1970, to determine the advantages and/or disadvantages of remote analog and/or remote computer control, it was decided to build one of the lines utilizing remote Direct Digital Control (DDC). In FY71 funds were allocated to build three more CIL TNT lines and in June 1972 a decision was made to incorporate DDC on those lines.

One of the DDC lines was operated from November 1974 until March 1977. During this time, the computer was proven to be reliable and able to control the process. Many modifications were made to the operating equipment and control system. At the present time, modifications to the control system are being completed.

The computer-aided manufacturing equipment at VAAP consists of a dual computer control system. The system is a Foxboro PCP-88 DDC computer system. It consists of two basic subsystems: the control computer and main data bus subsystems, and the supervisory computer subsystem.

The supervisory computer subsystem provides the basic equipment and programming to control the process (main data bus subsystem) in the event of a failure on the control computer subsystem. It also constitutes a facility for additonal program development and higher level control functions (optimization programs, etc.).

The supervisory software is a group of on-line, time-shared core resident and drum-resident programs and data tables that operate on a predetermined priority basis system program execution.

2. Active and Planned Efforts No reply.

3. Projected CAM Needs

At present, there are two CIL TNT lines and two acid and fume recoveries which could be added to the existing DDC system. Funds should be made available to accomplish this for many reasons such as uniformity in equipment and training requirements.

The acid plants could be operated much more efficiently if they were provided a better monitoring and control system, such as Mini-Computer Control. It is recommended that the processes be examined to see if this would be feasible.

One of the major problems with controlling the CIL process (either with analog or computer control) is the ability to quickly and accurately obtain acid and nitrobody analysis. The present method of analysis is to manually take samples and make manual analysis. To help reduce this problem, it is recommended that on-stream automatic analyzers be developed for the TNT process. The lack of on-stream analyzers is the only remaining deterrent to total automation of the process.

AVRADCOM

1. CAM History

Although the US Army Aviation Systems Research and Development Command (AVRADCOM) does not currently have any significant CAM facilities of its own, each of its major subcontractors does have such capabilities.

CAM Facilities at Prime Helicopter Manufacturers

- Boeing Vertol had some CAM efforts on-going during the UTTAS competition. With the loss of the competition, this effort was stopped.

- Sikorsky Aircraft CAM efforts are concentrated in two areas - N/C programming and process planning. The N/C programs are developed from detail data stored in a computer or from digitized data. The programs are developed for five-axis machine, lathes, and for sheet metal working. In addition to these N/C machines, Sikorsky has an N/C contact measurement system in use. Sikorsky currently has approximately thirty (30) pieces of N/C equipment installed and is planning to acquire another thirteen (13).

  Processing planning is accomplished at Sikorsky by an interactive "Q&A" routine for sheet metal, fiberglass and extruded material operations. The output of this system is a hard copy operation sheet. It is anticipated that this system will be expanded to also handle electrical and hydraulic process planning. It is planned to incorporate an automatic issuance of tool design orders based on requirements of the printed operation sheets.

CAM Facilities at Prime Helicopter Manufacturers (cont'd)

- o Bell Helicopter has the Lockheed CADAM system on line at the Hurst plant. Design data stored in their computer is used for tool design. The N/C programmer uses an extension of CADAM to prepare NC tapes for controlling lathes, milling machine, drill, routers, and so forth. A textronic scope is used for N/C tape and checkout equipment in use at Bell. Also a computer aided process planning system is on line. Currently, approximately eight (8) scopes are tied into the CADAM system and it is anticipated that the system will be expanded to approximately 75 scopes. As the capabilities of the CADAM system are developed and utilized, it can be expected that the numbers and types of N/C equipment in use at Bell will be increased.

- o Hughes Helicopters possess approximately ten (10) pieces of N/C equipment which they program via an APT program module on a time shared UCC computer. Hughes currently does not have any CAD capabilities or automated process planning on the CAM side. Extensive use of computers/scopes/CRT's is made by automated data collection of labor hours, expended in the shop areas, in production control, and inventory status accounting. Hughes has proposed to develop a CADAM system for support of the AAH program.

2. Active and Planned Efforts

AVRADCOM currently supervises at least three MMT projects having an NC/CAM impact or dependance. Three active or planned projects are described here.

Project 7175 - Automated Rotor Blade Contour Inspection/Computer Aided Inspection (FY 79-80)

- The objective of the project is to design and develop a computer aided measurement system to automatically inspect contours of spars and airfoils of helicopter rotor blades.

Project 7183 - Semi-automated Composite Manufacturing System for Helicopter Fuselage Secondary Structures (FY 78-81)

- The objective of the project is to demonstrate the feasibility of using a semi-automated composite manufacturing system for the production of composite helicopter fuselage parts. The automated composite laminating system assembled by Grumman under Air Force funding will be used to fabricate suitable AAH and Black Hawk composite components.

Project 7248 - Closed Loop Machining T700 Midframe (FY 79-81)

- This project will develop machine sensors using linear transducers that will automatically compensate for any deviation in the numerical controlled (NC) programmed plan, thereby reducing production costs. The system will automatically make tool corrections and feed back measured dimensional data by integrating automatic inspection with NC machining via the use of a computer.

3. Projected CAM Needs   No reply.

CORADCOM

1. CAM History

The US Army Communications Research and Development Command (CORADCOM) began in 1977 when the US Army Electronics Command (ECOM) was reorganized into three new commands.

The Electronics Command at Fort Monmouth installed its first Numerical Control Machine tool in 1967.

The years between 1967 and 1970 were devoted to the establishment of a technical base for CAM, a long term capital equipment expansion plan, and training plan for machinists, planners, and shop managers in the field in the effective use of CAM technology.

This time frame also saw a concentrated effort in the marketing of the evolving technology as a useful and cost effective tool in the communication electronics development cycle. In 1970 the CAD-E/CAM Division was established to implement the technology into the Command structure. The years between 1970 and 1974 produced significant improvements in the CAM capabilities of the Command. The inventory of NC machine tools included three vertical milling machines, a printed circuit board drill and a turning center. Programming support for these equipments included ADAPT computer part programming, an NC drafting, digitizing programming system and a coordinate measuring system. Nineteen hundred seventy-four through 1976 produced CAM system software development and improvements for symbol storage libraries, interactive printed circuit layout, automatic conductor paths offset generation, NC machining data dissemination and collection, interactive graphical part programming, and microwave filter design and manufacturing.

For the most part, these subject areas were addressed to enhance the Command's capability to efficiently produce communications electronics equipments.

In 1977 as a result of the AMARC recommendations, the Secretary of the Army announced the reorganization of ECOM into three new Commands: ERADCOM, the Electronics Research & Development Command; CORADCOM, the Communications Research & Development Command; and CERCOM, the Communications and Electronics Materiel and Development Command. With this reorganization all CAM resources, with the exception of an interactive graphics system and a data repository system were transferred to ERADCOM. The level of in-house CAM support or services has not yet been determined by CORADCOM.

The Command has also sponsored contractual studies in numerical control language evaluations (1973, 1976) and in realtime detection of printed circuit board drill failure (1976).

Due to the recent establishment of CORADCOM, the role of CAM in the mission requirements has not yet been defined. As this role is established, technology development can proceed.

CAM History (cont'd)

The level of CAM at principal contractors varies with the contractor. In general, the larger the contractor, the more sophisticated the use of CAM.

2. Active and Planned Efforts No reply.

3. Projected CAM Needs No reply.

DESCOM

1. CAM History

Presently, within the US Army Depot Systems Command (DESCOM) there are only five (5) depots who have Numerical Control Equipment (NCE). These include Anniston Army Depot (ANAD) (quantity of two each NCE), Corpus Christi Army Depot (CCAD) (quantity of eight each NCE), Tooele Army Depot, (TEAD) (quantity of five each NCE), Tobyhanna Army Depot (TOAD) (quantity of six each NCE), and Sacramento Army Depot (SAAD) (quantity of one each NCE). All other DESCOM depots have made no plans, or have no maintenance mission where NCE could be effectively justified. There are currently twenty-two (22) pieces of NCE within DESCOM, and one (1) each Interactive Graphics Design System (located at CCAD).

The earliest study was conducted at TEAD in February 1966. A three-year implementation plan recommmended the acquisition of four (4) NCE, and the first machine was received and installed in November 1966. The remaining three (3) NCE were obtained in 1967. In 1968, a follow-on study was conducted to determine if continued modernization of the original 175 conventional machine tools was necessary. This study recommended the acquisition of a Vertical Mill, an NC Lathe, and NC 3 Axis Milling, Drilling, and Boring Machine (with contouring capabilities), and a 60 ton NC Punch Press. The NC lathe was never procured, although it was justified in 1966, 1968, and other years since. In March 1977, another modernization study, conducted by the US Army Industrial Base Engineering Activity, Rock Island, Illinois, recommended the acquisition of an NC Lathe (with contouring capability) an NC Horizontal 3 Axis Milling, Drilling, and Boring Machine, and a 60 ton 2 Axis NC Punch Press. This appears to repeat the previous study recommendations. The NC Lathe was subsequently acquired as excess from Lexington-Blue Grass Army Depot.

The second earliest study was conducted at CCAD in 1968 and 1969, by the US Army Production Equipment Agency (PEQUA), which resulted in the acquisition of an NC Milling, Drilling, and Boring Machine, and two (2) NC Lathes. Five (5) additional NC machines have since been acquired, and in 1970, a Cordax Measurement and Inspection Machine was acquired. In 1971, the Interactive Graphics Design System was acquired, which provides CCAD with Computer-Aided Design (CAD) capability. Investigative studies were conducted at SAAD in 1969, but continuous delays have prevented the acquisition of any NCE until recently, when an NC Punch Press was transferred from Lexington-Blue Grass Army Depot. It, however, is incomplete. The programming computer, the hydraulic system, and the instruction service manuals, and other accessories, were being shipped separately.

CAM History (cont'd)

With the exception of the Interactive Graphics Design System and the Cordax Measurement System at CCAD, all other NC units have been programmed manually. There are no time-sharing terminals in any installations as of this date, therefore, no computer assisted part programming has been established, although there are three (3) Computer Numerical Control (CNC) Machine Tools in the system. One (1) NC Programming Terminal had been requested by TOAD. Also requested was a Depot Maintenance Plant Equipment (DMPE) program for an Analog/Digital Computer for programming of additional CNC machines.

2. Active and Planned Efforts

The study conducted by SAAD for DESCOM should clarify and define the conditions, parameters, controls, and operating criteria for NC equipment. It also provides a greater awareness to all DESCOM depots as to the capabilities and benefits of NC/CAM. At the conclusion, each DESCOM depot has been visited by the study team and functions, tasks, and operations which are currently being performed with conventional methods, and which should be done on NC, have been evaluated and identified. Finally, specific items of NC/CAM equipment are identified for each DESCOM depot to perform appropriate functions. The study was to be completed in August 1979, and the final results should provide a marked improvement in the use of NC/CAM equipment and technology within the Depot Systems Command.

3. Projected CAM Needs No reply.

ERADCOM

1. CAM History

The US Army Electronic Research and Development Command's (ERADCOM) Harry Diamond Laboratories (HDL) has built up its CAM facilities over the years in order to support the development efforts of its in-house scientists and engineers. Its first piece of CAM equipment, a Pratt and Whitney drill press, was acquired in 1962. This numerically controlled (N/C) drill remained the only piece of N/C equipment until 1969 when a Gorton Numeriturn III lathe was obtained for the mechanical fabrication shop and a multispindle N/C drill was acquired in the electronic fabrication shop for preparation of printed circuit boards (PCB's). From 1972 to 1974, several computer aids were obtained to expedite the process of going from engineering design to the N/C operation. One example was a Computer Vision (CV) Designer System that was acquired for use in PCB fabrication. This turn-key system enables the PCB to be layed out on a cathode ray tube (CRT) and then automatically generates control data for the photo plotter and tapes for the N/C drill.

Investigation of the use of UNIAPT, a minicomputer based APT system, began in 1974 on a trial basis. As a temporary host, a PDP-8I 12-bit minicomputer was used. The PDP-8I had been acquired in 1971 to control the automated Cordax coordinate measurement inspection equipment, a function it still performs today.

CAM History (cont'd)

Although test results appeared promising, the PDP-8I was too small a computer to process tasks much larger than academic APT problems. Therefore, acquisition of a larger minicomputer system was planned.

Equipment acquired in late 1975 consisted of a CV system for mechanical parts layout and a Digital Equipment Corporation (DEC) PDP-11/35 to be used for UNIAPT applications. Also acquired in 1975 was a Burgmaster N/C drill for the mechanical fabrication shop and an automatic scanner, used to digitize hand drawn PCB's, was added to the electronic fabrication shop's CV system. In 1976 and 1977, three pieces of N/C equipment were added to the mechanical fabrication facility: a Cincinnati-Millicron machining center, a Strippit sheet metal punch, and a Pratt and Whitney Starturn lathe.

The primary supplier for APT processing has remained GE Timesharing. Various in-house approaches investigated such as APT checking on the IBM 7094 and APT on the IBM 370 have not proved cost effective because of the personnel support that is required. The use of UNIAPT may prove to be an effective solution to performing the APT processing in-house but proving out the post-processors remains a problem that may preclude using this approach.

2. Active and Planned Efforts

The primary effort involves the integration of the computer aided design (CAD) and CAM areas. A large minicomputer is being acquired that will link together the various pieces of CAD and CAM equipment enabling a job, for example, to go from the engineers design to the produced and inspected part with a minimum of human intervention. Furthermore, data generated during this process will feed into the technical data package that will eventually go to industry.

3. Projected CAM Needs

HDL has several requirements for CAM equipment that are not currently funded. Fulfillment of these requirements will enable CAM techniques to be extended to additional in-house projects, thus improving productivity and the quality of the resulting work. Specifically, the following items are needed:

- Small N/C Mill - Allow more use of N/C on smaller projects that do not currently justify setting up the large N/C mill.

- N/C Wire Electric Discharge Machine (EDM) - Used to make molds for precision parts used in prototypes and field tests.

- N/C Jig Borer - Provide precise, repeatable boring of parts.

- Replacement of Two Existing N/C Controllers - Two of the existing N/C controllers, the Bunker-Ramo 3100 and the Sperry-Rand UMAC 7 are out of production and repair/maintenance is becoming more difficult and more costly. Replacement of these controllers with newer items will increase the machines mean time between failure (MTBF) and reduce the mean time to repair (MTTR), thus providing better utilization of the existing equipment.

Projected CAM Needs (cont'd)

- o Tape Prove-Out System - Existing graphics equipment has the capability to display tool paths but the software is either non-existant or primitive. Acquisition of such software would enable machine operation to commence without making trial runs with other expendable materials (e.g. wood).

- o Large Screen Display for CV System - The existing 5" by 10" display screen on the CV system makes it difficult to examine details of parts without time delaying zooming. A larger screen would eliminate much of this delay.

Additional work is required in integrating CAD and CAM facilities and operations so that these technologies can be used in a more effective manner. Industry has spent large sums of money developing similar systems and the Army could benefit by making use of these tools and techniques, appropriately modified for the Army environment. One or more organizations with an integrated background in computer aided design, computer aided manufacturing, and computer technology should be evaluating these packages with the intent of applying them to Army problems.

MERADCOM

1. CAM History

The US Army Mobility Equipment Research and Development Command (MERADCOM) was previously called ERDL.

In 1967 the then Engineer Research and Development Laboratories (ERDL) took one step to modernize their prototype manufacturing equipment by acquiring a Pratt and Whitney Model C, Numerical Control Tape Drill/Mill 3 axis machine. The table size is 29 x 45 inches, drilling capability in steel 2" in Dia., accuracy of positioning $\pm$ .001.

NC tapes are generated on a Friden "Flexowriter", the tapes are 1" wide 8 channel EIA.

The machine proved to be popular and cost effective in producing small lots for prototype equipment. The additional capability for manual control and digital readout of table position has improved the potential for error-free machining and more rapid production.

2. Active and Planned Efforts

No additional equipment has been acquired because of skilled personnel constraints created by reductions in force and the increase emphasis to increase the ratio of out-of-house contracting to in-house prototype manufacturing.

Efforts are to stay fully informed of the state of CAM technology thru acquisition of complete files from the CAM equipment manufacturers and attendance at industry

Active and Planned Efforts (cont'd)

sponsored seminars and expositions. The types of equipment which could be of benefit in manufacturing R&D prototypes are two sizes of machining centers and numerical control/digital readout measuring equipment.

3. Projected CAM Needs No reply.

MIRADCOM

1. CAM History

The US Army Missile Research and Development Command (MIRADCOM) Technology Laboratory was very active in the DARCOM CAD-E program during the time that program was active. This participation initiated a number of CAD-E/CAM activities, several of which are still active in the Laboratory.

2. Active and Planned Efforts

A Multi-Station Mechanical Design System (MSMDS) is operational for parametric and detail design. A digital data base and material selection program for the automatic selection of materials for design is operational, and automatic non-destructive test methods utilizing speckle interferometry and acoustical holography have been developed.

3. Projected CAM Needs No reply.

NARADCOM

1. CAM History

In 1975, the US Army Natick Research and Development Command (NARADCOM), Clothing Branch of the Clothing, Equipment and Materials Engineering Laboratory installed a computer processing system. The system consists of a digital input device, a central processing unit, an interactive video display terminal, alpha-numeric teleprinters, and a flat bed plotting or cutting device. The equipment with associated software has the basic capability of digitizing a master pattern with applicable numerical growth data, processing this data and grading the patterns to include all sizes required in a standard military tariff, and plotting or cutting all sizes on standard pattern cardboard.

The first step in the process is the development of an original or master pattern from an established set of sizing rules. A designer then traces over this master with a digital plotter, feeding the computer precise measurements of the pattern's dimensions.

After the computer accepts the pattern, the operator feeds in the necessary growth data and directs the system to design and grade the alternate sizes required. Each pattern size for the particular design is then stored in the computer's "memory."

CAM History (cont'd)

The memory data can be recalled for review and, if necessary, style changes and pattern alterations may be made through a telescreen and digital control apparatus.

Using the computer-operated pattern maker, designers at the Army's Natick Research and Development Command have been able to reduce the producton time of pattern grading operation from days, and sometimes weeks, to a matter of hours. As a result, actual development and production costs are dramatically reduced.

The system allows for complete standardization of Army clothing patterns by eliminating the persistent problem of individual differences on designer sizing methods. In addition, to the basic capabilities of digitizing, grading, and cutting of patterns, the system has the capability of redesigning existing clothing items by operator/system interaction to create new patterns.

The computer pattern processing system has improved this Command's generation capability, reduce cost of pattern fabrication, improve pattern data storage and recall. Established a standard pattern grading procedure and improved the quality and reproducibility of the government master patterns.

Project No. A7420lN Numerically Controlled Helmet Die Sinking (CAM Related)

The object of the subject project was to apply numerical control (NC) manufacturing techniques and software, using systems available in the public domain, to produce helmet tooling (dies and molds). The concept envisioned a library of source tapes, copies of which could be furnished to manufacturers in lieu of drawings. These source tapes would include a base program to prepare the date for subsequent NC processing, and the NC part programs to produce NC cutting tapes to manufacture the desired tooling.

A canvas of industry by means of a contract solicitation resulted in offerings of proprietary systems only.

An AD HOC task group was formed to study and recommend a program that would provide the Army a non-proprietary NC capability for producing helmet dies and molds.

A scope of work encompassing the proposed program was prepared. Thirteen DOD agencies were solicited for proposals to accomplish and phase(s) or portion(s) of the program. Four DOD agencies responded to the solicitation.

Customer Orders were awarded to:

a. Army Management and Engineering Activity (AMETA) to develop suitable source programs to cut sculptured surfaces (contours of helmets) on a 5-axis numerically controlled machines. to

b. Naval Research Laboratory to verify AMETA's programs on a 5-axis numerically controlled machines.

c. Picatinny Arsenal to develop source programs and manufacture molds to cut contours and make production type molds of a 3 size helmet system as represented by the newly proposed combat helmet. These programs were to be based on point-to-point measurements.

Project No. A74201N Numerically Controlled Helmet Die Sinking (CAM Related) (cont'd)

The Picatinny Arsenal program is continuing. Molds are now being manufactured. The program(s) undertaken by AMETA and NRL has been completed and is summarized in report, "A Computerized Complex Surface Manufacturing System" Volume I. Volumes II and III of the study contain "Flow Charts for Development Programs" and printouts of the programs respectively.

The subject project was to provide a means of manufacturing helmets and similarly complex surfaces. Using NC technology, application of these advanced techniques offers promise of lower procurement costs and greater reliability and quality among manufacturers. The AMETA effort conclusively illustrates that sculptured surface compiler systems now in the public domain (non-proprietary) cannot provide the capability to machine a helmet's complex surface. Only through memberships to special group efforts or through licenses of proprietary compiler systems could the Army (or other DOD agencies) avail themselves of the NC capability to machine complex sculptured surfaces.

Helmet developers and manufacturers have not yet availed themselves of the benefits of NC technology for design and fabrication. If the Army is to realize the advantages and savings that would accrue through NC, the Army will have to develop and furnish non-proprietary software to foster competitive bidding of helmet procurements.

Although this project did not successfully achieve its objectives, it did develop a realistic picture of the Army's shortcomings in the area of available Numerical Control Compilers. Consequently, it is recommended that the Army review its resources, current capabilities and posture with respect to using NC technology as an aid in the material acquisiiton and procurement processes. It is further recommended that the Army undertake a program that will ultimately provide the capabilities now lacking; a program that will improve the design and manufacturing functions through the use of non-proprietary Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) techniques.

2. Active and Planned Efforts

Project No. 7778053 (5397) - MMT CAD/CAM of Parachute Hardware

This task is to make a determination of a scientific method of designing and manufacturing forging dies for parachute hardware items based on computer aided design and computer aided manufacturing techniques.

A solution is necessary to eliminate dependence on the vanishing skills of the individual die designer and die maker, and thereby improve procurement conditions, product uniformity, and set the ground work for application to other forged military hardware.

The major objective is to identify and quantify the documented and undocumented knowledge of the skilled die designer and die maker necessary to fabricate a die capable of producing an item to a preestablished design. Develop a computer program which will in effect design the forging die set cavities from the part design.

A contract was awarded to Worcester Polytechnic Institute (WPI) Jan 1978 to accomplish the above work.

3. Projected CAM Needs   No reply.

TARADCOM

1. CAM History

The Metals/Welding Sub-Function of the US Army Tank-Automotive Research and Development Command (TARADCOM) Systems Lab has an automated 5-axis numerically controlled gas-metal arc welder. It employs an automated positioning table capable of locating work so that all welds can be deposited in the flat welding position. The gas-metal arc welding gun is directed by an eddy-current sensing seam tracking device and drive motors. The numerical control is implemented by a PDP/11 processor with teletype and punched tape. The welder is used to produce multi-pass welds in armor plate in both the horizontal and verticle positions. The arc can be positioned anywhere in a 6' cube and can weld to radii as small as 4".

The Fabrication Division of the Engineering Support Directorate has had numerical control machines (Milwaukee and Burgmaster) since 1963.

Two CAM efforts have recently been completed at TARADCOM. The first is the Computer-Aided Design & Manufacturing for Closed-Die Forging of Track Shoes and Links, supervised by AMMRC and funded by TARADCOM. A computerized method was developed for designing blocker and finisher dies for forging track shoes and links, and for manufacturing blocker dies by numerical control machining. This CAD/CAM system can be applied to a wide variety of nonsymmetric forgings, yielding increases in die life and reductions in die cost.

The other program is Automated Gas Metal Arc Welding of Steel in more than one axis. A computer-controlled automatic welding system was designed and built using commercially available components. The system can follow a weld joint based on information obtained from an eddy-current sensing probe. The machine affords five axes of control, including two rotational axes, in a numerical control mode. A mini-computer coordinates and interprets all control functions, including operator inputs from a control panel. Steel armor H-plates were fabricated using this machine. The technology appears to be applicable to aluminum armor also. Benefits will be increased production speeds, improved reliability and ability to weld multiple sections of wrought armor plate simultaneously.

2. Active and Planned Efforts

One currently funded CAM project is an Improved Foundry Casting Process Utilizing Computer-Aided Fluid Flow and Thermal Analysis. A CAD methodology is being developed to locate and size gates and risers in castings so that defects (e.g., shrinkages) can be avoided and scrap can be reduced. Thermal analysis will be used with computer graphics to simulate the mold filling process. The pattern

shape will be adjusted by using an interactive terminal to effect design optimization. The pattern will be generated by numerical control machining, yielding a CAM foundry process.

Another current project is Gear Die Design and Manufacturing Using Computer Technology. A CAD technique will be developed for transforming dimensional data from engineering drawings of bevel gears into a die design, considering such parameters as flash volume, forging load and surface finish. Dies will be produced by CAM techniques with NC or EDM. The CAD/CAM system will reduce die manufacturing costs and scrap losses in gear production.

A program for Laser Weldings of the Turbine Engine Recuperator of the AGT 1500 engine for the XM-1 tank uses CAM technology to direct the laser beam travel over the weld path. The benefit is in increased welding speed.

Starting with FY79 a program in Flexible Machining Systems was initiated. This program will involve a very complex CAM approach to bring the benefits of Transfer Machine Technology (automation) to smaller production runs of a variety of parts.

XM-1 facilitization is including CAM systems. Multiple machining centers and a first generation flexible machining system are on order.

3. Projected CAM Needs

In the furture there will be efforts to apply CAM to welding. It is anticipated this will require an effort to develop adaptive control systems to maintain process control.

AMMRC

1. CAM History

There are seven NC machine tools (Table-1) on line at the US Army Materials and Mechanics Research Center (AMMRC). Since there are no CAM facilities, all tools are programmed manually.

TABLE-1

MANUFACTURER	TYPE	MODEL	CONTROL	AXES
American	Engine lathe	3019 x 96	GE 102C	2
Bridgeport	Mill	83-500	MOOG	2
Brown & Sharpe	Turret Drill	234	GE 100	3
Cincinnati	Drill	Cintimatic	220	2
Fosdick	Jig Borer	54-P	Fosmatic	3
Kearney & Trecker	Machining Center	2	GE NCC	3
Kearney & Trecker	Machining Center	2	GE NPC	3

CAM History (cont'd)

This Center has participated in the advancement of CAM technology through the technical supervision of the following funded efforts on deformation processing:

1. CAD/CAM for Extrusion of Aluminum, Titanium and Steel Structural Parts (Phase I) March, 76.

2. CAD/CAM for Closed-Die Forging of Track Shoes and Links, July, 76.

3. CAD/CAM for Extrusion of Aluminum, Titanium, and Steel Structural Parts (Phase II), June, 78.

These efforts focused on the development of computer-aided techniques for analyzing and simulating metal flow. The application of these techniques, along with advanced NC tool manufacture, will ultimately provide for the practical use of CAD/CAM in these metal forming processes.

2. Active and Planned Efforts

There are no currently funded efforts at this Center in the CAM technology area. Additional CAM developments in themselves, would not have significant impact at this activity until such time as host facilities and equipment become available.

3. Projected CAM Needs

Access to a CAM system such as United Computing Corporation's Unigraphics would provide support to this Center's current NC machine tools as well as to provide an excellent base for equipment modernization. This system would allow for the selection of tool geometry, entry of tool into workpiece, relationship between tool motion and part surfaces and other parameters including feed rates, spindle speed, coolant flow, etc. An interactive system would also provide for visual editing and verification of cutter tool paths on a CRT display in real time. The acquisition and integration of CNC would provide existing conventional NC equipment with the exceptional flexibility inherent in software operations.

APPENDIX A

DARCOM REGULATION 15-13

SAMPLE

*DARCOM-R 15-13

DEPARTMENT OF THE ARMY
HEADQUARTERS US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND
5001 Eisenhower Ave, Alexandria, VA 22333

DARCOM REGULATION
No. 15-13

3 June 1977

Boards, Commissions, and Committees

DARCOM COMPUTER AIDED MANUFACTURING (CAM)
STEERING GROUP

1. Purpose. This regulation establishes and prescribes the mission, organization, and functions of the US Army Development and Readiness Command (DARCOM) Computer Aided Manufacturing (CAM) Steering Group, an advisory board to the Chief, Office of Manufacturing Technology and the Associate Director for the Industrial Base of HQ, DARCOM.

2. Scope. This regulation applies to Headquarters, DARCOM; DARCOM major subordinate commands; and laboratories and activities reporting directly to HQ, DARCOM.

3. Mission. The DARCOM Computer Aided Manufacturing Steering Group will:

a. Develop a systematic, time-phased CAM Plan (RCS:DRCMT-304) for implementation of numerical control machines and the development and evolution of CAM within Army.

b. Monitor the execution of this plan, making recommendations as appropriate.

c. Work with training activities to develop the educational programs that are required for the successful utilization of CAM.

d. Insure maximum implementation of developments and interchange of information within DARCOM; as well as exchange information with other services, Government agencies, and private industry.

*This regulation replaces AMCR 15-13, dated 18 August 1970.

SAMPLE

e. Provide a forum to assure the interface of Computer Aided Design (CAD) with Computer Aided Manufacturing.

4. Organization. The CAM Steering Group will consist of a representative from each major subordinate command; arsenals, laboratories, and activities will be represented as deemed appropriate to perform the mission. (Membership is restricted to Federally employed individuals.) The group Chairman will be an appointee from the Manufacturing Technology Division of the US Army Industrial Base Engineering Activity.

5. Functions. The DARCOM Computer Aided Manufacturing Steering Group will act in an advisory capacity to the Chief, Office of Manufacturing Technology and the Associate Director for the Industrial Base of HQ, DARCOM. Consonant with the group mission, it will perform actions necessary to insure the cost effective utilization of the computer in the total manufacturing system.

6. Responsibilities. The group will perform a significant portion of its actions by telephone and mail with coordination being accomplished by the group chairman,but will meet annually and more frequently if deemed necessary by the chairmen. The chairman will be responsible for coordinating actions among the members, maintaining records, calling meetings as necessary, and publishing and annually updating the CAM plan.

(DRCMT)

FOR THE COMMANDER:

OFFICIAL:

H. B. GIBSON, JR.
Major General, USA
Chief of Staff

G. J. HAROLD
LTC, GS
Adjutant General

DISTRIBUTION:
A and B

APPENDIX B

Letters Requesting CAM Plan Information

1. DRXIB-MT, IBEA, 21 June 1977
2. DRXIB-MT, IBEA, 13 February 1978
3. DRCMT, DARCOM, 18 April 1978
4. DRXIB-MT, IBEA, 25 August 1978

DEPARTMENT OF THE ARMY
US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY
ROCK ISLAND, ILLINOIS 61201

DRXIB-MT 8 1 JUN 1977

SUBJECT: Computer Aided Manufacturing (CAM) Steering Group

SEE DISTRIBUTION

1. Reference is made to DARCOM-R 15-13, DARCOM Computer Aided Manufacturing Steering Group, dated 3 June 1977 (Incl. 1).

2. The Army is currently spending millions of dollars annually in the development and utilization of Computer Aided Manufacturing (CAM) systems. Along with the most publicized area of Numerical Control (NC) machinery, systems are being developed and utilized in inspection, data collection and analysis, process control, simulation, shop loading and control, group technology, etc. This effort is being funded through a variety of Army appropriations and is occurring in depots, arsenals, research laboratories, GOCO's, and private contractors' plants.

3. Because of the magnitude and diversity of the effort, information interchange and coordinated planning are considered essential. To accomplish this, DARCOM has directed (see reference above) this Activity to establish a CAM Steering Group. The members of this group (CAM representatives) should be production oriented and will function primarily as a network for information exchange. They will also be annually required to provide raw input to the CAM Plan, which this Activity will edit and publish. This plan will document current capabilities, future plans, contact points, etc. Although the format, content, and quality of this document will be largely decided by the cooperation and participation of the CAM Representatives, a strawman outline for this plan is attached as Incl. 2.

4. As a first step in achieving these objectives, it is necessary to establish the CAM Representatives. If your activity is active (or plans to be active) in CAM, please provide us the name of your CAM Representative. We desire both command and installation representation. Negative replies are requested.

VANGUARD OF FREEDOM UNITED STATES ARMY

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

DRXIB-MT
Subject: Computer Aided Manufacturing (CAM) Steering Group

21 JUN 1977

5. The Chairman of the CAM Steering Group, Mr. Ronald Geiss, AV 793-5235, will contact your CAM Representative in the near future to discuss CAM Group actions. Please feel free to contact him should you have further questions.

J R Gallaugher

2 Incl.
as

J. R. GALLAUGHER
Director,
Industrial Base Engineering Activity

DISTRIBUTION:
Cdr, ARRCOM, ATTN: DRSAR
Cdr, ARRADCOM, ATTN: DRDAR
Cdr, AVSCOM, ATTN: DRSAV
Cdr, DESCOM, ATTN: DRSDS
Cdr, ECOM, ATTN: DRSEL
Cdr, MIRCOM, ATTN: DRSMI
Cdr, MIRADCOM, ATTN: DRDMI
Cdr, TARADCOM, ATTN: DRDTA
Cdr, TARCOM, ATTN: DRSTA
Cdr, TECOM, ATTN: DRSTE
Cdr, TROSCOM, ATTN: DRSTS
Cdr, MERADCOM, ATTN: DRDME
Cdr, NARADCOM, ATTN: DRXNM
Cdr, USAILCOM, ATTN: DRCIL
Cdr, EWA, ATTN: SAREA
Cdr, FFA, ATTN: SARFA
Cdr, PBA, ATTN: SARPB
Cdr, RIA, ATTN: SARRI
Cdr, Rocky Mountain Arsenal, ATTN: SARRM
Cdr, WVA, ATTN: SARWV
Cdr, Holston AAP, ATTN: SARHO
Cdr, Indiana AAP, ATTN: SARIN
Cdr, Iowa AAP, ATTN: SARIO
Cdr, Joliet AAP, ATTN: SARJO
Cdr, Kansas AAP, ATTN: SARKA
Cdr, Lake City AAP, ATTN: SARLC
Cdr, Lone Star AAP, ATTN: SARLS
Cdr, Longhorn AAP, ATTN: SARLO
Cdr, Louisiana AAP, ATTN: SARLA
Cdr, Milan AAP, ATTN: SARMI
Cdr, Radford AAP, ATTN: SARRA
Cdr, Riverbank AAP, ATTN: SARRB
PM, Munitions Prod. Base Mod. and Exp., ATTN: DRCPM-PBM-DP

2 1 JUN 1977

DRXIB-MT
Subject: Computer Aided Manufacturing (CAM) Steering Group

DISTRIBUTION (Cont'd):
Cdr, Scranton AAP, ATTN: SARSC
Cdr, Twin Cities AAP, ATTN: SARTC
Cdr, Volunteer AAP, ATTN: SARVO
Cdr, Anniston Army Depot, ATTN: DRXAN
Cdr, Corpus Christi Army Depot, ATTN: DRXAD
Cdr, Letterkenny Army Depot, ATTN: DRXLE
Cdr, Lexington-Blue Grass Army Depot, ATTN: DRXLX
Cdr, New Cumberland Army Depot, ATTN: DRXNC
Cdr, Red River Army Depot, ATTN: DRXRR
Cdr, Sacramento Army Depot, ATTN: DRXSA
Cdr, Seneca Army Depot, ATTN: DRXSE
Cdr, Sharpe Army Depot, ATTN: DRXSH
Cdr, Sierra Army Depot, ATTN: DRXSI
Cdr, Tobyhanna Army Depot, ATTN: DRXTO
Cdr, Tooele Army Depot, ATTN: DRXTE
Cdr, Navajo Army Depot Activity, ATTN: DRXTE-N
Cdr, Pueblo Army Depot Activity, ATTN: DRXPU
Cdr, Savanna Army Depot Activity, ATTN: DRXAC
Cdr, Umatilla Army Depot Activity, ATTN: DRXTE-UM
Cdr, Fort Wingate Army Depot Activity, ATTN: DRXFW
Dir, AMMRC, ATTN: DRXMR
Cdr, Army Ballistic Research Labs, ATTN: DRXBR-X
Cdr, HDL, ATTN: DRXDO
Dir, Army Human Engineering Labs, ATTN: DRXHE
Cdr, Night Vision Labs, ATTN: DRSEL-NV-PA/IO
Cdr, Army Logistics Management Center, ATTN: DRXMC-AL
Dir, AMETA, ATTN: DRXOM
Cdr, Joint Military Packing Training Center, ATTN: DRXPP-A
Dir, Automated Logistics Management Systems Activity, ATTN: DRXAL-A
Cdr, Logistics System Support Activity, ATTN: DRXLS-L
Cdr, Foreign Science and Technology Center, ATTN: DRXST-OC
Cdr, Army Equipment Authorizations Review Activity, ATTN: DRXEA-C
Cdr, Army Maintenance Management Center, ATTN: DRXMD
Cdr, Army Research Office, ATTN: DRXRO-AO

CF:
Cdr, ARRCOM, ATTN: DRSAR-IMM
Cdr, ARRADCOM, ATTN: DRDAR-PMM
Cdr, AVSCOM, ATTN: DRSAV-EXT
Cdr, ECOM, ATTN: DRSEL-PP-I-PI
Cdr, MERADCOM, ATTN: DRDME-U
Cdr, MIRADCOM, ATTN: DRDMI-EAT
Cdr, NARADCOM, ATTN: DRXNM-EM
Cdr, TARADCOM, ATTN: DRDTA-RKA
Cdr, TARCOM, ATTN: DRSTA-E

2 1 JUN 1977

DRXIB-MT
Subject: Computer Aided Manufacturing (CAM) Steering Group

CF (Cont'd):
Cdr, TECOM, ATTN: DRSTE-ME
Cdr, TROSCOM, ATTN: DRSTS-PLC
Dir, AMMRC, ATTN: DRXMR-PT
Cdr, HDL, ATTN: DRXDO-PP
Cdr, AMRDL, ATTN: SAVDL-TAS
Cdr, FFA, ATTN: SARFA-MTT
Cdr, PTA, ATTN: SARPA-MT-C
Cdr, RIA, ATTN: SARRI-RLR
Cdr, WVA, ATTN: SARWV-RS
Cdr, DARCOM, ATTN: DRCPM-PBM-LN1
DOD, The Pentagon, ATTN: OASD (I&L) WP, Dr. Lloyd L. Lehn
HQDA, The Pentagon, ATTN: OASD (I&L), Mr. E. S. Davidson
HQDA, ODCSRDA, The Pentagon, ATTN: DAMA-PPM-P, Mr. Rod Vawter
Cdr, DARCOM, ATTN: DRCMM, DRCCG, DRCDMD, DRCDMR, DRCPP, DRCPP-I, DRCDE, DRCMT
Chf, Office of Project Management, ATTN: DRCPM

SAMPLE

*DARCOM-R 15-13

DEPARTMENT OF THE ARMY
HEADQUARTERS US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND
5001 Eisenhower Ave, Alexandria, VA 22333

DARCOM REGULATION
No. 15-13

3 June 1977

Boards, Commissions, and Committees

DARCOM COMPUTER AIDED MANUFACTURING (CAM) STEERING GROUP

1. Purpose. This regulation establishes and prescribes the mission, organization, and functions of the US Army Development and Readiness Command (DARCOM) Computer Aided Manufacturing (CAM) Steering Group, an advisory board to the Chief, Office of Manufacturing Technology and the Associate Director for the Industrial Base of HQ, DARCOM.

2. Scope. This regulation applies to Headquarters, DARCOM; DARCOM major subordinate commands; and laboratories and activities reporting directly to HQ, DARCOM.

3. Mission. The DARCOM Computer Aided Manufacturing Steering Group will:

a. Develop a systematic, time-phased CAM Plan (RCS:DRCMT-304) for implementation of numerical control machines and the development and evolution of CAM within Army.

b. Monitor the execution of this plan, making recommendations as appropriate.

c. Work with training activities to develop the educational programs that are required for the successful utilization of CAM.

d. Insure maximum implementation of developments and interchange of information within DARCOM; as well as exchange information with other services, Government agencies, and private industry.

*This regulation replaces AMCR 15-13, dated 18 August 1970.

Incl 1

e. Provide a forum to assure the interface of Computer Aided Design (CAD) with Computer Aided Manufacturing.

4. Organization. The CAM Steering Group will consist of a representative from each major subordinate command; arsenals, laboratories, and activities will be represented as deemed appropriate to perform the mission. (Membership is restricted to Federally employed individuals.) The group Chairman will be an appointee from the Manufacturing Technology Division of the US Army Industrial Base Engineering Activity.

5. Functions. The DARCOM Computer Aided Manufacturing Steering Group will act in an advisory capacity to the Chief, Office of Manufacturing Technology and the Associate Director for the Industrial Base of HQ, DARCOM. Consonant with the group mission, it will perform actions necessary to insure the cost effective utilization of the computer in the total manufacturing system.

6. Responsibilities. The group will perform a significant portion of its actions by telephone and mail with coordination being accomplished by the group chairman,but will meet annually and more frequently if deemed necessary by the chairmen. The chairman will be responsible for coordinating actions among the members, maintaining records, calling meetings as necessary, and publishing and annually updating the CAM plan.

(DRCMT)

FOR THE COMMANDER:

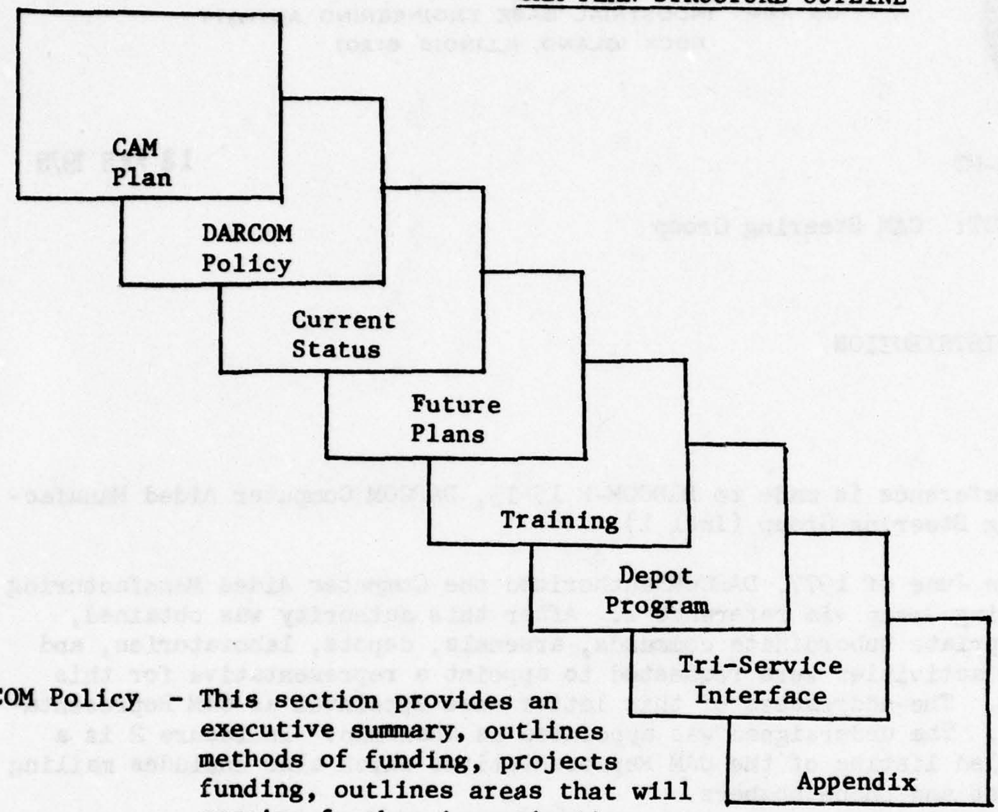
OFFICIAL:

H. B. GIBSON, JR.
Major General, USA
Chief of Staff

G. J. HAROLD
LTC, GS
Adjutant General

DISTRIBUTION:
A and B

CAM PLAN STRUCTURE OUTLINE



DARCOM Policy - This section provides an executive summary, outlines methods of funding, projects funding, outlines areas that will require further investigation, etc.

Current Status - This could be a summary by Command, of what has been done to date, highlighting significant achievements. A summary of in-house installation history and capability could also be included.

Future Plans - This section could outline currently funded and future efforts.

Training - This section could outline the DARCOM CAM oriented courses.

Depot Program - This section could outline the depot program, including the status of those depots involved in NC/CAM. Projections of future actions could be extracted from the Depot Five Year Plan.

Tri-Service Interface - This could be a summary of other Service efforts, highlighting areas of common interest.

Appendix - This section could contain copies of pertinent regulations, policy letters, technical association endorsement, definition of CAM terms, contact points, etc.

DEPARTMENT OF THE ARMY
US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY
ROCK ISLAND, ILLINOIS 61201

DRXIB-MT

13 FEB 1978

SUBJECT: CAM Steering Group

SEE DISTRIBUTION

1. Reference is made to DARCOM-R 15-13, DARCOM Computer Aided Manufacturing Steering Group (Incl 1).

2. In June of 1977, DARCOM authorized the Computer Aided Manufacturing Steering Group via reference 1. After this authority was obtained, appropriate subordinate commands, arsenals, depots, laboratories, and other activities were requested to appoint a representative for this group. The addressees of this letter were appointed as CAM Representatives. The undersigned was appointed as Chairman. Inclosure 2 is a detailed listing of the CAM Representatives which also includes mailing address and phone numbers.

3. The regulation authorizes a formal network for information exchange and requires publication of an annual CAM Plan. To implement information exchange, I plan to distribute an information letter to you, on a somewhat regular basis, discussing capabilities, problems, needs, future plans, etc., of the CAM community. This, quite obviously, will only be successful if we keep in contact by letter or phone, and you provide me with news.

4. Further information exchange can be effected through the Army Manufacturing Technology Bulletin, which gets a wide distribution throughout DOD. (You, as a CAM Representative, are now on the distribution list.) If you provide input, a CAM News page could be incorporated in this Bulletin. This would provide wide visibility to Army's CAM actions.

5. You can expect guidance for the CAM Plan to arrive in about one month. As currently envisioned, this guidance will avoid producing a lengthy plan consisting of a "wish list" of many individual projects. Rather, I would hope that we produce a concise plan which narratively lists and discusses present capabilities, currently funded efforts, and those efforts which are not now funded but you believe to be needed in the near future.

VANGUARD OF FREEDOM
BICENTENNIAL
UNITED STATES ARMY

AMERICAN REVOLUTION BICENTENNIAL 1776-1976

13 FEB 1978

DRXIB-MT
Subject: CAM Steering Group

6. Obviously, members and membership in this committee will not remain static. If the information on Inclosure 2 is no longer correct, please bring it to my attention.

7. I'm looking forward to hearing from you. If you have suggestions, comments, or questions, please let me know. My address and phone are at the top of Inclosure 2.

Ronald J. Geiss

2 Incl
as

RONALD J. GEISS
Chairman,
CAM Steering Group

DISTRIBUTION:
Cdr, TSARCOM, ATTN: DRSTS-PLE, James Corwin
Cdr, AVRADCOM, ATTN: DRDAV-EXT, Fred Reed
Cdr, MERADCOM, ATTN: DRDME-DE, Bernard Bretz
Cdr, NARADCOM, ATTN: DRXNM-D, Irving Tarlow
Cdr, ERADCOM, ATTN: DRSEL-PP-I-PI, James Kelly
Cdr, ERADCOM, ATTN: DRSEL-GG-C, Dave Ruppe
Cdr, HDL, ATTN: DRXDO-TS, Robert Rosen
Cdr, MIRADCOM, ATTN: DRDMI-EAT, Richard Kotler
Cdr, MIRADCOM, ATTN: DRDMI-TL, Richard Eppes
Cdr, TARCOM, ATTN: DRSTA-IZ, Dan Urso, John DeBolle
Cdr, TARADCOM, ATTN: DRDTA-RKAC, Ed Moritz
Cdr, ARRCOM, ATTN: DRSAR-MSE, Thomas Frandsen
Cdr, ARRCOM, ATTN: DRSAR-IMB-PW, Gerald Hall
Cdr, ARRADCOM, ATTN: DRDAR-TSF-P, Stan Hart
Cdr, ARRADCOM, ATTN: DRDAR-TSI-CS, Carl Bealieu
PM, MPBM&E, ATTN: DRCPM-PBM-T-TA, Douglas Morlock
Cdr, EWA, ATTN: Chemical Systems Lab, DRDAR-CLT-B, Kenneth Coulsen
Cdr, RIA, ATTN: SARRI-AO, J. F. Schwegler, Ray Kirshbaum
Cdr, RMA, ATTN: SARRM-AD, John Reynolds
Cdr, WVA, ATTN: SARWV-ODP, Karl Klingenberger
Cdr, Indiana AAP, ATTN: SARIN-EN, Gary McCloskey
Cdr, Iowa AAP, ATTN: SARIO-EN, Joseph Carter
Cdr, Lone Star AAP, ATTN: SARLS-EN, Larry Henry
Cdr, Radford AAP, ATTN: SARRA-XC, John Horvath
Cdr, Riverbank AAP, ATTN: SARRB, Don Keith
Cdr, Scranton AAP, ATTN: SARSC-EN, William Haynes
Cdr, DESCOM, ATTN: DRSDS-PMI, Harry Dell
Cdr, Corpus Christi AD, ATTN: SDSCC-MPI, Roy Oliver
Cdr, Letterkenny AD, ATTN: DRXLE-MN, Raymond Amicone
Cdr, Sacramento AD, ATTN: DRXSA-MPC-1, Steven Hull

DRXIB-MT 13 FEB 1978

Subject: CAM Steering Group

DISTRIBUTION (Continued):
Cdr, Tobyhanna AD, ATTN: SDSTO-ME, Robert Marmo
Cdr, Tooele AD, ATTN: SDSTE-MAG, Lee Williams
Dir, AMMRC, ATTN: DRXMR-ER, Roger Gagne
Dir, AMETA, ATTN: DRXOM-SE, Alvin Takemoto

COMPUTER AIDED MANUFACTURING REPRESENTATIVES

NAME	OFFICE SYMBOL	ADDRESS	AUTOVON
Ronald Geiss	DRXIB-MT	Director US Army Industrial Base Engineering Activity Rock Island, IL 61299	793-5235
James Corwin	DRSTS-PLE	Commander US Army Troop Support and Aviation Readiness Command 4300 Goodfellow Blvd St. Louis, MO 63120	693-3417
Fred Reed	DRDAV-EXT	Commander US Army Aviation Research and Development Command 12th & Spruce Streets St. Louis, MO 63166	698-6476
Bernard Bretz	DRDME-DE	Commander US Army Mobility Equipment Research and Development Command Ft. Belvoir, VA 22060	354-5726
Irving Tarlow	DRXNM-D	Commander US Army Natick Research and Development Command Natick, MA 01760	955-2349
James Kelly Dave Ruppe	DRSEL-PP-I-PI DRSEL-GG-C	Commander US Army Electronics Command Ft. Monmouth, NJ 07703	992-4993
Robert Rosen	DRXDO-TS	Commander Harry Diamond Laboratories 2800 Powder Mill Road Adelphi, MD 20783	290-2917
Richard Kotler Richard Eppes	DRDMI-EAT DRDMI-TL	Commander US Army Missile Research and Development Command Redstone Arsenal Huntsville, AL 35805	746-3524
Dan Urso John DeBolle	DRSTA-IZ DRSTA-IZ	Commander US Army Tank-Automotive Materiel Readiness Command Warren, MI 48090	369-2223

Incl 2

NAME	OFFICE SYMBOL	ADDRESS	AUTOVON
Ed Moritz	DRDTA-RKAC	Commander US Army Tank-Automotive Research and Development Command Warren, MI 48090	273-1347
Thomas Frandsen Gerald Hall	DRSAR-MSE DRSAR-IMB-PW	Commander US Army Armament Materiel Readiness Command Rock Island, IL 61299	793-4701 793-5590
Stan Hart Carl Bealieu	DRDAR-TSF-P DRDAR-TSI-CS	Commander US Army Armament Research and Development Command Dover, NJ 07801	880-3472 880-6231
Douglas Morlock	DRCPM-PBM-T-TA	Project Manager Munitions Production Base Modernization and Expansion Dover, NJ 07801	880-2135
Kenneth Coulsen	DRDAR-CLT-B	Commander Edgewood Arsenal Chemical Systems Lab Aberdeen Proving Ground, MD 21010	584-3350
J. F. Schwegler Ray Kirshbaum	SARRI-AO SARRI-AO	Commander Rock Island Arsenal Rock Island, IL 61299	793-5528 793-5363
John Reynolds	SARRM-AD	Commander Rocky Mountain Arsenal Denver, CO 80240	556-2391
Karl Klingenberger	SARWV-ODP	Commander Watervliet Arsenal Watervliet, NY 12189	974-5719
Gary McCloskey	SARIN-EN	Commander Indiana Army Ammunition Plant Charlestown, IN 47111	366-7403
Joseph Carter	SARIO-EN	Commander Iowa Army Ammunition Plant Middletown, IA 52638	551-1561

NAME	OFFICE SYMBOL	ADDRESS	AUTOVON
Larry Henry	SARLS-EN	Commander Lone Star Army Ammunition Plant Texarkana, TX 75501	829-1305
John Horvath	SARRA-XC	Commander Radford Army Ammunition Plant P.O. Box 121 Radford, VA 24141	931-8641
Don Keith	SARRB	Commander Riverbank Army Ammunition Plant Claus and Claribel Roads Riverbank, CA 95367	466-4236
William Haynes	SARSC-EN	Commander Scranton Army Ammunition Plant 156 Cedar Avenue Scranton, PA 18502	938-1790 ext. 302
Harry Dell	DRSDS-PMI	Commander US Army Depot Systems Command Chambersburg, PA 17201	242-6321
Roy Oliver	SDSCC-MPI	Commander Corpus Christi Army Depot Corpus Christi, TX 78419	861-3242
Raymond Amicone	DRXLE-MN	Commander Letterkenny Army Depot Chambersburg, PA 17201	242-7077
Steven Hull	DRXSA-MPC-1	Commander Sacramento Army Depot Sacramento, CA 95801	839-2601
Robert Marmo	SDSTO-ME	Commander Tobyhanna Army Depot Tobyhanna, PA 18466	247-9491
Lee Williams	SDSTE-MAG	Commander Tooele Army Depot Tooele, UT 84074	290-2860

NAME	OFFICE SYMBOL	ADDRESS	AUTOVON
Roger Gagne	DRXMR-ER	Director US Army Materials and Mechanics Research Center Watertown, MA 02172	955-3436
Alvin Takemoto	DRXOM-SE	Director US Army Management Engineer- ing Training Agency Rock Island, IL 61299	793-4041

DEPARTMENT OF THE ARMY
HEADQUARTERS US ARMY MATERIEL DEVELOPMENT AND READINESS COMMAND
5001 EISENHOWER AVE., ALEXANDRIA, VA. 22333

S: 31 May 1978

DRCMT

18 APR 1978

SUBJECT: CAM Plan Input

SEE DISTRIBUTION

1. Reference is made to DARCOM Regulation 15-13, DARCOM Computer Aided Manufacturing (CAM) Steering Group, dated 3 June 1977.

2. The referenced regulation requires that the CAM Steering Group prepare a plan outlining the DARCOM program for CAM. The plan will be prepared by the steering group chairman based on input from the members.

3. As steering group members, you are requested to input the data identified in Inclosure 1 to Mr. R. Geiss, Steering Group Chairman by 31 May 1978.

FOR THE COMMANDER:

1 Incl
as

JOHN H. TIPTON, JR.
Colonel, GS
Chief, Office of
Manufacturing Technology

DRCMT 18 APR 1978

Subject: CAM Plan Input

DISTRIBUTION:

Cdr, ARRCOM, ATTN: DRSAR-MSE, Thomas Frandsen
Cdr, ARRCOM, ATTN: DRSAR-IMB-PW, Gerald Hall
Cdr, ARRADCOM, ATTN: DRDAR-TSF, Stan Hart
Cdr, ARRADCOM, ATTN: DRDAR-TSI-CS, Carl Bealieu
Cdr, AVRADCOM, ATTN: DRDAV-EXT, Dan Haugan
Cdr, DESCOM, ATTN: DRSDS-PMI, Harry Dell
Cdr, ERADCOM, ATTN: DELSD-D-PC, James Kelly
Cdr, ERADCOM, ATTN: DRSEL-GG-C, Dave Ruppe
Cdr, MIRADCOM, ATTN: DRDMI-EAT, Richard Kotler
Cdr, MIRADCOM, ATTN: DRDMI-TL, Richard Eppes
Cdr, TARADCOM, ATTN: DRDTA-RKAC, Ed Moritz
Cdr, TARCOM, ATTN: DRSTA-IZ, Dan Urso, John DeBolle
Cdr, TSARCOM, ATTN: DRSTS-PLE, James Corwin
Cdr, MERADCOM, ATTN: DRDME-DE, Bernard Bretz
Cdr, NARADCOM, ATTN: DRDNA-D, Irving Tarlow
Cdr, EWA, ATTN: DRDAR-CLT-B, Kenneth Coulsen
Cdr, RIA, ATTN: SARRI-AO, J. F. Schwegler, Ray Kirschbaum
Cdr, RMA, ATTN: SARRM-AD, John Reynolds
Cdr, WVA, ATTN: SARWV-ODP, Karl Klingenberger
Cdr, Indiana AAP, ATTN: SARIN-EN, Gary McCloskey
Cdr, Iowa AAP, ATTN: SARIO-EN, George Mathes
Cdr, Lone Star AAP, ATTN: SARLS-EN, Larry Henry
Cdr, Radford AAP, ATTN: SARRA-XC, John Horvath
ICI Americas, Inc., Volunteer AAP, ATTN: Ken Mallone, P.O. Box 6008, Chattanooga, TN 37401
Cdr, Riverbank AAP, ATTN: SARRB, Don Keith
PM, APBM&E, ATTN: DRCPM-PBM-T-TA, Douglas Morlock
Cdr, Scranton AAP, ATTN: SARSC-EN, Williom Haynes
Cdr, Corpus Christi Army Depot, ATTN: SDSCC-MPI, Roy Oliver
Cdr, Letterkenny Army Depot, ATTN: SDSLE-MN, Raymond Amicone
Cdr, Sacramento Army Depot, ATTN: SDSSA-MPC-1, Steven Hull
Cdr, Tobyhanna Army Depot, ATTN: SDSTO-ME, Robert Marmo
Cdr, Tooele Army Depot, ATTN: SDSTE-MAG, Lee Williams
Dir, AMMRC, ATTN: DRXMR-ER, Roger Gagne
Cdr, HDL, ATTN: DELHD-TS, Robert Rosen
Dir, AMETA, ATTN: DRXOM-SE, Alvin Takemoto

GUIDANCE FOR CAM PLAN

The CAM Steering Committee consists of a wide variety of individuals each representing a different DARCOM organization. Each organization has a slightly different association with CAM. In order to assure the guidance is appropriate to these diverse organizations, an overall list of topics has been identified. Specific topics of relevance to your organization have been identified below.

Provide a narrative discussion on the topics marked with a check. At your discretion, you may also wish to comment on the un-checked topics. The "check" technique will avoid overlap in input; however, because you are the principle source for the information on the checked topics, it is required that you provide complete data.

_______1. Describe the CAM facilities, equipment, and software at your installation. The report should be written with historical perspective, culminating in a description of those facilities now being installed or funded for installation. An example of an input that would satisfy item 1 is attached.

_______2. Describe the additional (presently unfunded) CAM equipment and facilities that you feel are needed at your installation.

_______3. Describe recently completed efforts that you've sponsored which contributed to CAM technology developments.

_______4. Describe currently active (funded) efforts that you are sponsoring which will contribute to CAM technology development.

_______5. Describe the additional (unfunded) CAM technology development efforts that you feel would benefit your command, installation, or activity.

_______6. Describe the state-of-the-art of CAM at your principle contractors.

If questions of problems arise, contact Mr. Ronald Geiss at AUTOVON 793-5235.

(EXAMPLE)

CAM Facilities at Rock Island Arsenal

Rock Island Arsenal installed its first NC machine tool in 1958. Under a continuing modernization program, additional acquisitions have been made to obtain the current complement of 50 NC machine tools.

In-house computer support came in 1966. It was in that year that the Arsenal Operations Directorate installed an automated data collection system. Seventy-five terminals located in nine buildings were used to transmit production and labor information to a Control Data 160A computer which generated many production status and labor efficiency reports. This same system drove the Arsenal's cost accounting and customer billing systems. In this type of system, the prime advantages realized were timeliness and the keypunch cost savings which resulted from using data collection output as computer input without modification.

In 1971, Rock Island Arsenal installed a Direct Numerical Control system called Sundstrand Omnicontrol. In this system, a Digital Equipment Corporation PDP-11/20 computer controlled and monitored the operations of five numerically controlled machine tools. Cathode ray tubes located at each machine and in the programming department were used to conversationally generate parts programs and then to optimize those programs at the machine site as the machine was being run. Tape prove-out time was reduced significantly and machine cycle times proved to be much shorter because the ease with which programs could be modified tended to encourage optimizations which otherwise would have been impractical.

The installation of the Direct Numerical Control system lead to the solution of two additional CAM problems that had plagued RIA for years. First of all, the UNIAPT computer-assisted parts programming language was installed on the PDP-11/20 computer and was expanded to the point where today it can handle the programming for approximately 50 of RIA's numerically controlled machine tools. Because these machines were programmed manually in the past, estimated savings have been conservatively set between $75,000 and $100,000 yearly. Secondly, the Direct Numerical Control computer allowed RIA to take its first step towards solving its most significant problem, i.e., the lack of a good production and inventory control system. Under a CAM contract, the IIT Research Institute developed programs for the PDP-11/20 computer designed to utilization monitoring, and job history monitoring. The success of this system gave RIA its first exposure to the potential of on-line processing and lead to additional work on AOD's production and inventory control problem.

In 1973, RIA began work on a program called PASLACS (Pilot Automated Shop Loading and Control System) which promises to solve most of RIA's production and inventory control problems. A commercial P&IC software package called Production IV is being installed on ARRCOM's IBM 360/65 computer which should allow RIA to increase the productivity of its entire direct labor work force, thereby reducing the cost and production leadtimes for all of its products. The Production IV package uses all of the standard techniques recognized by the authorities in the field as being the keys to the modern computerized production and inventory control system including Material Requirements Planning, Capacity Requirements Planning, Input/Output Control, and Dispatching. The PASLACS program is scheduled for completion in December of 1978.

RIA has recently had its initial exposure to Computerized Numerical Control (CNC). These systems use a dedicated minicomputer to control the motions of a single numerical control machine. Reliability is increased as many of the traditional electro-magnetic elements of a conventional N/C control system have been replaced by software. These systems provide the added feature of allowing programs to be optimized on the shop floor.

RIA also has a complement of computerized coordinates measuring machines. These systems, purchased over the last several years, are used for inspection and testing.

The Arsenal has received funding to install a computerized Group Technology System. ARRCOM is purchasing the system for Rock Island, Watervliet, and the Dover installations. The contractor will be named shortly.

DEPARTMENT OF THE ARMY
US ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY
ROCK ISLAND, ILLINOIS 61299

DRXIB-MT 25 AUG 1978

SUBJECT: Computer Aided Manufacturing (CAM) Plan

SEE DISTRIBUTION

1. Reference is made to DRXIB-MT letter dated 21 Jun 77, Subject: Computer Aided Manufacturing (CAM) Steering Group.

2. The Manufacturing Technology Division has received most of the anticipated inputs to the CAM Plan and is integrating these inputs into a final report. For those organizations that have not responded to the request for data (Reference 1), please do so by COB 13 Oct 78 so that your data may be included in the Plan. The Rock Island Arsenal input is provided as a guide (Incl. 1).

3. The CAM Plan is being finalized by Mark Brauer, AV 793-3734/3682. Please contact him should you have any questions.

James W. Carstens

1 Incl
as

JAMES W. CARSTENS
Chief, Manufacturing Technology Division
Industrial Base Engineering Activity

Note: Retyped at IBEA for reproduction clarity.

DRXIB-MT

SUBJECT: Computer Aided Manufacturing (CAM) Plan

DISTRIBUTION:

Cdr, TROSCOM, ATTN: DRSTS-PLE, James Corwin
Cdr, AVRADCOM, ATTN: DRDAV-EXT, Fred Reed
Cdr, MERADCOM, ATTN: DRDME-DE, Bernard Bretz
Cdr, NARADCOM, ATTN: DRXNM-D, Irving Tarlow
Cdr, HDL, ATTN: DELHD-TS, Robert Rosen
Cdr, MIRADCOM, ATTN: DRDMI-EAT, Richard Kotler
Cdr, MIRADCOM, ATTN: DRDMI-TL, Richard Eppes
Cdr, TARCOM, ATTN: DRSTA-IZ, Dan Urso, John DeBolle
Cdr, TARADCOM, ATTN: DRDTA-RKAC, Ed Moritz
Cdr, ARRCOM, ATTN: DRSAR-MSE, Thomas Frandsen
Cdr, ARRCOM, ATTN: DRSAR-IMB-PW, Gerald Hall
Cdr, ARRADCOM, ATTN: DRDAR-TSF-P, Stan Hart
Cdr, ARRADCOM, ATTN: DRDAR-TSI-CS, Carl Bealieu
PM, MPBM&E, ATTN: DRCPM-PBM-T-TA, Douglas Morlock
Cdr, EWA, ATTN: Chemical Systems Lab, DRDAR-CLT-B, Kenneth Coulsen
Cdr, RIA, ATTN: SARRI-AO, J. F. Schwegler, Ray Kirshbaum
Cdr, RMA, ATTN: SARRM-AD, John Reynolds
Cdr, WVA, ATTN: SARWV-ODP-S, George Anderson
Cdr, Indiana AAP, ATTN: SARIN-EN, Gary McCloskey
Cdr, Iowa AAP, ATTN: SARIO-EN, Joseph Carter
Cdr, Lone Star AAP, ATTN: SARLS-EN, Larry Henry
Cdr, Radford AAP, ATTN: SARRA-XC, John Horvath
Cdr, Riverbank AAP, ATTN: SARRB-ER, Don Keith
Cdr, Scranton AAP, ATTN: SARSC-EN, William Haynes
Cdr, DESCOM, ATTN: DRSDS-PMI, Harry Dell
Cdr, Corpus Christi AD, ATTN: SDSCC-MPI, Roy Oliver
Cdr, Letterkenny AD, ATTN: DRXLE-MN, Raymond Amicone
Cdr, Sacramento AD, ATTN: SDSSA-C, Russ Harris
Cdr, Tobyhanna AD, ATTN: SDSTO-ME, Robert Marmo
Cdr, Tooele AD, ATTN: SDSTE-MAG, Lee Williams
Dir, AMMRC, ATTN: DRXMR-ER, Roger Gagne
Dir, AMETA, ATTN: DRXOM-SE, Alvin Takemoto
Cdr, ERADCOM, ATTN: DELET-DT, Berni Reich
Cdr, CORADCOM, ATTN: DRDCO-TCS-CT, Sam Esposito
Cdr, CERCOM, ATTN: DRSEL-LE-RI, Morton Eichel

I. ROCK ISLAND ARSENAL

A. CAM HISTORY

Rock Island Arsenal (RIA) installed its first NC machine tool in 1958. Under a continuing modernization program, additional acquisitions have been made to obtain the current complement of more than 50 NC machine tools.

In-house computer support came in 1966. It was in that year that the Arseanl Operations Directorate (AOD) installed an automated data collection system. Seventy-five terminals located in nine buildings were used to transmit production and labor information to a Control Data 106A computer which generated many production status and labor efficiency reports. This same system drove the Arsenal's cost accounting and customer billing systems. In this type of system, the prime advantages realized were timeliness and the keypunch cost savings which resulted from using data collection output without modification.

In 1971, RIA installed a Direct Numerical Control (DNC) system called Sundstrand Omnicontrol. In this system a Digital Equipment Corporation PDP-11/20 computer controlled and monitored the operations of five NC machine tools. Cathode ray tubes located at each machine and in the programming department were used to conversationally generate parts programs and then optimize those programs at the machine site as the machine was being run. Tape prove-out time was significantly reduced and machine cycle time was shortened. The latter was due to program modification ease which tended to encourage optimization that otherwise would have been impractical.

The installation of the DNC system lead to the solution of two additional CAM problems that had plagued RIA for years. First of all, the UNIAPT computer-assisted parts programming language was installed on the PDP-11/20 computer and was expanded to the point where today it can handle the programming for approximately 50 of RIA's machine tools. Because these machines were manually programmed in the past, estimated savings have been conservatively set between $75,000 and $100,000 yearly. Secondly, the DNC computer allowed RIA to take it's first step towards a good production and inventory control (P&IC) system. Under a CAM contract, the IIT Research Institute developed programs for the PDP-11/20 computer designed for utilization monitoring and job history monitoring. The success of this system gave RIA its first exposure to the potential of on-line processing and lead to additional work on P&IC.

More recently, RIA had its initial exposure to a new technology called Computerized Numerical Control (CNC). This systems uses a dedicated minicomputer, PDP-8 to control the motions of a single NC machine. Many of the traditional electro-magnetic elements of a conventional NC system have been replaced by software and initial success with this system at RIA indicates a bright future for CNC. In some respects, CNC systems are similar to computerized coordinate measuring machines which are inspection devices that have been used at this Arsenal for years.

Incl 1

Finally, in 1973, RIA began work on a program called PASLACS (Pilot Automated Shop Loading and Control System) which today looks like it is going to be the solution to most of RIA's P&IC problems. A commercial software package marketed by Informatics, called Production IV, was installed on the local IBM 360/65 computer allowing RIA to increase the productivity of its entire direct labor work force and thereby reduce the cost and production leadtimes for all of its products. The PASLACS program, detailed below, is currently being used as a standard productction tool at RIA (see paragraph D).

All of the CAM systems referred to in this plan are either being installed or have been installed and are still fully operational. CAM technology has been cosidered a vital part of this Arsenal's modernization program and will continue to be a part of our program in the future.

B. PLANNED IMPLEMENTATIONS AND/OR ACQUISITIONS

FY78

The RIA AOD is presently buying a terminal with access to the ARRCOM-S&E computer for use by the Plant Engineering staff.

FY79

Three NC controls for three existing American Lathes and one new unit for a Kearney & Trecker Turn-12 Machine are programmed for acquisition in FY-79. These control units are to replace units which have developed operational problems, making them expensive/unreliable to use.

The FY-79 budget contains a program to develop the application of Group Technology, including computer utilization. This is conceived of as first of a three year program.

FY80

During the FY-80 program, the first year of a three year series, a Shop Floor Feedback System is planned to develop a shop-floor/computer-interactive capability. This system is intended to replace the present punched card work-measurement Transactor system. Presently proposed for acquistion in FY-80 are:

One NC sheet metal punch and nibble machine

Two vertical profilers (double spindle)

Some (quantity undetermined) NC turret lathes

Four NC 4-axis shaft lathes

The majority of all available resources have been concentrated on PASLACS. Contributions have involved proofing, testing, modifying, and upgrading the

AD-A076 333 ARMY INDUSTRIAL BASE ENGINEERING ACTIVITY ROCK ISLAND IL F/G 9/2
SURVEY OF COMPUTER AIDED MANUFACTURING SYSTEMS WITHIN DARCOM. F--ETC(U)
SEP 79 A C ADLFINGER

UNCLASSIFIED NL

2 OF 2
ADA
076333

END
DATE
FILMED
11 -79
DDC

capabilities of the Production IV system and integration of this system into an Arsenal-Government environment. Also involved has been the necessity of interfacing a production control system with the Army's depot production support module Speedex system.

C. UNFUNDED ACTIVITY

Additional CAM technology development efforts that would benefit RIA but are yet unfunded include:

A system for using a computer for the development of labor standards. At present, most work measurement staffs devote a large amount of time to standards development, whereas methods improvement and other related efforts represent real opportunities for cost reductions. In many indirect labor areas, such standards as exist are presently meaningless for the most part. With improved systems for setting standards; productivity, productivity improvement, work scheduling, staffing requirements, etc., can be more effective.

Computer Assisted Process Planning is an area within which RIA has no present effort. The benefits, problems, etc. associated with Computerized Process Planning in the defense business are unknown, but likely to have an impact on defense contractors in the coming years.

A computer system for the selection of replacement equipment would be beneficial. At the present time, the equipment buy decisions are more intuition, based on samples or the opinions of a limited group of people. A computerized system would enable a more objective basis for decision making.

Another productive venture would include Optimal Process Planning. This involves computerizing the sequencing of operations as related to material flow in the shop, referred to as a flexible floor manufacturing system. There are several potential avenues for investigation here.

Preprocessors upgrading involving Adaptive Control would be desirable. This involves using the computer to establish machine tool cutting speeds and feed as the result of in-process measurement of such factors as tool force, motor power consumption, chip temperature, etc. to maintain a near optimum condition for machining at all times.

D. TYPICAL CAM PROJECT SUMMARY

1. PROJECT TITLE: Pilot Automated Shop Loading and Control System (PASLACS).

2. CAM AREA: Inventory Control; Management.

3. END ITEM SUPPORTED: All end items produced by Rock Island Arsenal will benefit from successflu completion of this project.

4. PROBLEM: Rock Island Arsenal's current production and inventory control system is unable to ensure compliance with cost and schedule objectives in the production of Army materiel. The current system merely collects status which becomes meaningless because adequate pre-planning has not been done.

5. SOLUTION: The PASLACS system is a customized version of Informatics' Production IV software package that is currently being installed on ARRCOM's IBM 360/65 computer. This system features tools such as Material Requirements Planning, Capacity Requirements Planning, Input/Output Control, and Dispatching. These tools allow for the scheduling of individual manufacturing operations and purchased material and, more importantly, provide the techniques required to ensure execution of the plan. Expected benefits of this program include reduced costs for all end items and shorter manufacturing leadtimes.

6. FUNDING PROFILE: This ARRCOM MM&T program was adequately funded for $280,000 in FY75, and $260,000 in FY76 (Project Numbers 675 7580 and 676 7580, respectively).

E. CONTACT: Mr. John A. Fox, Supv., Prod Control

Rock Island Arsenal

Rock Island IL 61299

Commercial (309) 794-6322

Autovon 793-6322

APPENDIX C

CAM REPRESENTATIVES

COMPUTER AIDED MANUFACTURING
STEERING GROUP REPRESENTATIVES

DARCOM

US Army Materiel Development and Readiness Command
Attn: DRCMT, Mr. Frederick J. Michel
5001 Eisenhower Avenue — AV: 284-8298/8299
Alexandria, VA 22333 — C: (703) 274-8298/8299

DARCOM

US Army Materiel Development and Readiness Command
Attn: DRCPP-IF, Major David Sims
5001 Eisenhower Avenue — AV: 284-8225/8226
Alexandria, VA 22333 — C: (703) 274-8225/8226

IBEA

US Army Industrial Base Engineering Activity
Attn: DRXIB-MT, Mr. Steve McGlone — AV: 793-3734
Rock Island, IL 61299 — C: (309) 794-3734

ARRADCOM

US Army Armament Research Development Command
Attn: DRDAR-TSF-P, Mr. Stanley Hart — AV: 880-3721/3472
Dover, NJ 07801 — C: (201) 328-3721/3472

ARRADCOM

US Army Armament Research Development Command
Attn: DRDAR-CLJ-B, Mr. Kenneth A. Coulson — AV: 584-3350
Chemical Systems Laboratory — C: (301) 328-3350
Aberdeen Proving Ground, MD 21010

ARRCOM

US Army Armament Materiel Readiness Command
Attn: DRSAR-MSE, Mr. Thomas Frandsen — AV: 793-4701
DRSAR-MSE, Mr. Stanley E. Mazur (Alternate) — AV: 793-4701
DRSAR-IRW-T, Mr. Gerald L. Hall — AV: 793-5590
Rock Island, IL 61299 — C: (309) 794-4701/5590

AVRADCOM

US Army Aviation Research and Development Command
Attn: DRDAV-EXT, Mr. Daniel Haugan — AV: 693-1625
P. O. Box 209 — C: (314) 263-1625
St. Louis, MO 63166

CORADCOM

US Army Communications Research and Development Command
Attn: DRDCO-PE-EC-1, Mr. James F. Kelly — AV: 955-4803/4745
Fort Monmouth, NJ 07703 — C: (201) 544-4803/4745

COMPUTER AIDED MANUFACTURING
STEERING GROUP REPRESENTATIVES (cont'd)

DESCOM
US Army Depot System Command
Sacramento Army Depot
Attn: SDSSA-C, Mr. Russel Harris — AV: 839-2518
Sacramento, CA 95813 — C: (916) 388-2518

ERADCOM
Harry Diamond Laboratories
Attn: DELHD-IR, Mr. Robert Rosen — AV: 290-2917
DELHD-I-RM, Mr. Harry Hill (Alternate) — AV: 290-3124
2800 Powder Mill Road — C: (301) 394-2917/3124
Adelphi, MD 20783

MERADCOM
US Army Mobility Equipment Research and Development Command
Attn: DRDME-DE, Mr. Bernard J. Bretz — AV: 354-5371
Fort Belvoir, VA 22060 — C: (703) 664-5371

MIRCOM and MIRADCOM (MICOM)
US Army Missile Research and Development Command
Attn: DRSMI-EAT (RND), Mr. Bobby Austin — AV: 746-7057
DRSMI-EAT (RND), Mr. Richard A. Kotler (Alternate) — AV: 746-2065
Engineering Laboratory — C: (205) 876-7057/2065
Redstone Arsenal, AL 35809

NARADCOM
US Army Natick Research and Development Command
Attn: DRDNA-EM, Mr. Irving Tarlow — AV: 955-2360
Natick, MA 01760 — C: (617) 653-1000

TARADCOM
US Army Tank-Automotive Research and Development Command
Attn: DRDTA-RCKM, Mr. Sam Goodman — AV: 273-1814/2065
Warren, MI 48090 — C: (313) 573-1814/2065

TARCOM
US Army Tank-Automotive Materiel Readiness Command
Attn: DRSTA-ICC, Mr. Chester Zack — AV: 273-3011
DRSTA-ICC, Mr. John DeBolle (Alternate) — AV: 273-3016
Warren, MI 48090 — C: (313) 5730 3011/3016

TSARCOM
HQ, US Troop Support & Aviation Materiel Readiness Command
Attn: DRSTS-PLEP-(2), Mr. James R. Corwin — AV: 693-0496/3366
DRSTS-PLEP-(2), Mr. Arthur Goldberger (Alternate) — AV: 693-0496/3366
4300 Goodfellow Boulevard — C: (314) 263-0496/3366
St. Louis, MO 63120

COMPUTER AIDED MANUFACTURING
STEERING GROUP REPRESENTATIVES (cont'd)

Arsenals

Rock Island Arsenal
Attn: SARRI-AOE, Mr. Richard Johnson — AV: 793-5925
Rock Island, IL 61299 — C: (309) 794-5925

Rocky Mountain Arsenal
Attn: SARRM-TOI, Mr. Dave Strang — AV: 556-2201
Denver, CO 80240 — C: (303) 288-0711 ext. 201

Watervliet Arsenal
Attn: SARWV-ODP-S, Mr. Dominick Ippolito
SARWV-ODP-S, Mr. George Anderson (Alternate) — AV: 974-5719
Watervliet, NY 12189 — C: (518) 266-4610 ext. 5719

Army Ammunition Plants

Indiana Army Ammunition Plant
Attn: SARIN-EN, Mr. Gary McCloskey — AV: 366-7403
Charlestown, IN 47111 — C: (812) 282-8961 ext. 7403

Iowa Army Ammunition Plant
Attn: SARIO-EN, Mr. George H. Mathes — AV: 585-7101
Middleton, IA 52638 — C: (319) 754-5731 ext. 710

Lone Star Army Ammunition Plant
Attn: SARLS-EN, Mr. Larry A. Henry — AV: 829-1305
Texarkana, TX 75501 — C: (214) 838-1305

Radford Army Ammunition Plant
Attn: SARRA-EN, Mr. John C. Horvath — AV: 931-8641
SARRA-EN, Mr. Gene Rhodes (Alternate) — AV: 931-8641
Radford, VA 24141 — C: (703) 639-8641

Riverbank Army Ammunition Plant
Attn: SARRB-ER, Mr. Don Keith — AV: 463-4236
Riverbank, CA 95367 — C: (209) 529-8100 ext. 4236

Scranton Army Ammunition Plant
Attn: SARSC-EN, Mr. William Haynes — AV: 938-1790 ext. 302
Scranton, PA 18501 — C: (717) 342-7801 ext. 302

Volunteer Army Ammunition Plant
Attn: SARVO-CO, Mr. James E. Fry — AV: 431-3750
Chattanooga, TN 37401 — C: (615) 892-0115

COMPUTER AIDED MANUFACTURING
STEERING GROUP REPRESENTATIVES (cont'd)

Depots

Corpus Christ Army Depot	
Attn: SDSCC-MPI, Mr. Roy Oliver	AV: 861-3243
SDSCC-MPDT, Mr. E. V. Garcia (Alternate)	AV: 861-2423
Corpus Christi, TX 78419	C: (512) 939-3243/2423
Letterkenny Army Depot	
Attn: SDSLE-MM, Mr. Richard Cordori	AV: 242-7693
SESLE-MM, Mr. Barton Patterson (Alternate)	AV: 242-7475
Chambersburg, PA 17201	C: (717) 263-7693/7475
Sacramento Army Depot	
Attn: SDSSA-MPE-4, Mr. William Humenick	AV: 839-3378
Sacramento, CA 05913	C: (916) 388-3378
Tobyhanna Army Depot	
Attn: SDSTO-ME-O, Mr. Robert L. Marmo	AV: 247-9491
Tobyhanna, PA 18466	C: (717) 894-8301
Tooele Army Depot	
Attn: SDSTE-MAS-SB, Mr. Lee Williams	AV: 290-2860
Tooele, UT 84074	C: (801) 833-2789

Project/Product Managers, Lab, Schools & Other Installations/Activities

US Army Materiel Development and Readiness Command	
Office of the Project Manager for Munitions	
Production Base Modernization and Expansion (PM, PBME)	
Attn: DRCPM-PBM-T, Mr. Douglas A. Morlock	AV: 880-6704
Dover, NJ 07801	C: (201) 328-6704
US Army Management Engineering Training Activity (AMETA)	
Attn: DRXOM-SE, Mr. Alvin K. Takemoto	AV: 793-4041
DRXOM-SE, Mr. James O. Young (Alternate)	AV: 793-4041
Rock Island, IL 61299	C: (309) 794-4041
US Army Materials and Mechanics Research Center (AMMRC)	
Attn: DRXMR-ER, Mr. Roger Gagne	AV: 955-3436
Watertown, MA 02172	C: (617) 923-3436

APPENDIX D

CAM MMT EFFORTS COMPLETED

This appendix contains a listing of CAM related MMT efforts completed in FY 75-79. Data presented for each effort includes the MMT effort number, command code, title, MMT effort FY, cost, a statement of the problem, a statement of the solution, and the technology area into which the effort is categorized. Data is displayed in two separate lists. The first list consists of those efforts where CAM is identified as a primary function. The second list consists of those efforts where CAM is identified as a secondary function.

EXPLANATION OF DATA PRESENTATION

1. Command Code - Refer to list of command codes and corresponding major subordinate commands or activities.

2. Project No. - MMT effort number.

3. Title - MMT effort title.

4. FY - Fiscal Year for MMT effort.

5. Cost - Total cost in thousands of dollars.

6. Cycle - Status of corresponding Fiscal Year MMT effort.

7. Problem - Description of the problem the MMT effort addresses.

8. Solution - Description of how the MMT effort proposes to solve the problem.

9. Technology Area - See "Technology Areas Descriptions."

Note: The "explanation of data presentation" also applies to data in Appendix E.

COMMAND CODES FOR MAJOR SUBORDINATE COMMANDS OR ACTIVITIES

Command Code	Major Subordinate Command/Activity Acronym
0	TECOM
1	AVRADCOM
2	CERCOM
3	MIRCOM
4	TARCOM
5	ARRCOM (Ammo)
6	ARRCOM (Weapons)
7	TSARCOM
8	ARRADCOM (Ammo)
9	ARRADCOM (Weapons)
D	DARCOM
E	MERADCOM
F	CORADCOM
H	ERADCOM
M	AMMRC
Q	NARADCOM
R	MIRADCOM
T	TARADCOM
I	IBEA
G	DESCOM

TECHNOLOGY AREAS DESCRIPTIONS

To aid in analyzing individual MMT efforts, each CAM related effort is categorized into one of the following technology areas. These tech areas were originally identified in the Air Force's ICAM Program and were refined by the MTAG CADCAM Subcommittee.

Underlying the optimum benefits obtainable from ultizing CAM technology is the systems approach. Interrelationships between the various subsystems within an organization must be taken into consideration. These technology areas represent the "system" and direct thinking toward an integrated approach.

100 ARCHITECTURE

The purpose of the manufacturing architecture is to provide a clear understanding of the manufacturing environment and the interrelationships between subsystems that exist today. The manufacturing architecture, or framework provides a common baseline in building integrated manufacturing systems.

200 FABRICATION

The fabrication technology area serves as a focus for all other technology area activities. Projects categorized into this area are directed toward increasing the productivity of manufacturing by systematically applying computer technology to all functions which directly and indirectly participate in fabricating parts.

300 DATA BASE/DATA AUTOMATION

Data base and data automation technology required to support integration of the many stages and disciplines of manufacturing.

400 CADCAM INTERACTION

The purpose of this technology thrust area is to establish subsystems and procedures which will integrate the efforts of product design and manufacturing. The underlying concept is that of a common data base between engineering and manufacturing.

500 PLANNING AND GROUP TECHNOLOGY

Technology directed at optimizing process planning, production scheduling and control, factory layout and other tasks normally performed by indirect personnel that have a significant impact on manufacturing cost.

600 MANUFACTURING CONTROL

Generic technology for producing management oriented information tools for scheduling, monitoring and controlling operations within the manufacturing environment. Closely related to the fabrication and planning and group technology areas.

700 ASSEMBLY

The integration of computer aided technology into assembly operations.

800 SIMULATION, MODELING AND OPERATIONS RESEARCH

Soft technology for optimizing manufacturing systems through the application of operations research techniques.

900 MATERIALS HANDLING AND STORAGE

The integration of computer aided technology to aid in material handling. Objectives here include complying with OSHA and EPA standards and reducing costs and materials handling time through automated material storage, handling, and retrieval systems.

1000 TEST, INSPECTION AND EVALUATION

Develop and transition real time, computerized, nondestructive testing techniques for use in fabrication and assembly operations. Emphasis is put on automatic, in-process inspection and decision making without human intervention.

1100 CONTINUOUS FLOW PROCESSES

This technology area addresses the range of manufacturing processes that, for the most part, are continuous with minimum human interaction.

PRIMARY CADCAM--COMPLETED PROJECTS
09/20/79

```
***
  COMMAND CODE   PROJ NO   TITLE                                                           FY    COST   CYCLE
***
*      H          9737     INTEGRATED PRINTED CIRCUIT EQUIP LAYOUT AND ASSEMBLY            75     662   COMPLETED

  PROBLEM                                     SOLUTION                                                  TECHNOLOGY AREA
***
* PRESENT METHODS OF ENGINEERING DEVELOPMENT AND PR   A COMPUTER-AIDED SYSTEM WILL BE ESTABLISHED IN WHI   SIM, MODEL, OP RESCH
  ODUCTION ALLOW TECHNICAL DATA PACKAGES TO REACH T   CH THE FUNCTIONAL AND MAN-MACHINE CHARACTERISTICS
  HE CONTRACTOR WITH INCONSISTENCIES, ERRORS, AND O   OF COMMUNICATION-ELECTRONICS (C-E) EQUIPMENT WILL
  MMISSIONS.                                          BE SIMULATED AND ASSESSED WELL BEFORE ACTUAL BREAD
                                                      BOARDING OR MANUFACTURE.

***
* ------------------------------------------------------------------------------------------------------------

  COMMAND CODE   PROJ NO   TITLE                                                           FY    COST   CYCLE
***
*      H          9832     AUTO WIREWRAP VERIFIER, CAM RELATED                             77      30   COMPLETED

  PROBLEM                                     SOLUTION                                                  TECHNOLOGY AREA
***
* WHEN A COMPUTER-CONTROLLED WIREWRAP MACHINE IS US   WRITE A PROGRAM FOR CHECKING CONTINUITY BETWEEN PI   TEST, INSP, EVAL
  ED TO WIRE A BACK PANEL, IT MUST BE RELOCATED ONT   NS THAT SHOULD BE CONNECTED.
  O A TEST BLOCK FOR VERIFYING ALL CONNECTIONS WERE
   PROPERLY MADE.

***
* ------------------------------------------------------------------------------------------------------------

  COMMAND CODE   PROJ NO   TITLE                                                           FY    COST   CYCLE
***
*      R          3232     COMPUTERIZED PRODUCTION PROCESS PLANNING                        77     225   COMPLETED
*                                                                                          76     100   COMPLETED

  PROBLEM                                     SOLUTION                                                  TECHNOLOGY AREA
***
* OPERATING PRESENT MANUFACTURING SYSTEMS REQUIRES    COMPUTER AIDED PRODUCTION PLANNING CAN BE USED TO    PLANNING/GROUP TECH
  EXTENSIVE PROCESS PLANNING EFFORT, PREPRODUCTION    REPLACE THE MANUAL APPROACH TO ACHIEVE EFFICIENCY.
  OPERATIONS ARE SUCH THAT THEIR COMPLETION TAKES L
  ONG PERIODS OF TIME.

***
* ------------------------------------------------------------------------------------------------------------
```

PRIMARY CADCAM--COMPLETED PROJECTS
09/20/79

***

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
T	4561	CLOSED DIE FORGING OF TRACK SHOES AND LINKS	75	134	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
FORGING DIES ARE DESIGNED AND MANUFACTURED THROUGH TRIAL AND ERROR METHODS, CONSIDERABLE SCRAP LOSSES, UNEXPECTED DIE WEAR AND BREAKAGE RAISE MANUFACTURING COSTS.	DEVELOP COMPUTER AIDED TECHNIQUES FOR MANUFACTURING FORGING DYES BY USING N/C MACHINING METHODS, OPTIMIZE DESIGN AND LIFE OF THE FORGING DIES.	CADCAM INTERACTION

***

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
T	5017	AUTOMATED WELDING OF ALUMINUM COMBAT VEHICLES	77	79	COMPLETED
			78	100	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
MANUAL WELDING IS TIME CONSUMING AND FATIGING.	DEVELOP IMPROVED AUTOMATED PROCESS TO WELD ALUMINUM HULLS.	FABRICATION CADCAM

***

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
1	8154	CADAM FOR EXTRUSION OF ALUMINUM, TI AND STEEL STRUCTUR PARTS	75	182	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
TO OBTAIN CLOSE TOLERANCES AND IMPROVED MECHANICAL PROPERTIES IN EXTRUDING COMPLEX CROSS SECTIONS THE EXTRUCION PROCESS MUST BE OPTIMIZED. CURRENTLY THIS IS ACCOMPLISHED USING EMPIRICAL GUIDELINES AND TRIAL-BY-ERROR METHODS.	DEVELOP A COMPUTER AIDED METHOD FOR THE ANALYSIS OF THE EXTRUDED PROCESS IN ORDER TO OPTIMIZE PROCESS PARAMETERS AND DIE DESIGN.	CADCAM INTERACTION

***

PRIMARY CADCAM--COMPLETED PROJECTS
09/20/79

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
1	8162	MODIFICATION OF NC LANGUAGE FOR AUTOMATED TAPE LAYUP SYSTEM	75	86	COMPLETED
			79	75	BUDGET

PROBLEM	SOLUTION	TECHNOLOGY AREA
AVAILABLE GENERAL PURPOSE NC LANGUAGES MAY PROVE ECONOMICALLY INFEASIBLE FOR MAKING VARIOUS REQUIRED REAL TIME ON-LINE CHANGES TO PROGRAMMED INSTRUCTIONS FOR THE ATLAS.	FORMULATE AN NC PROGRAMMING LANGUAGE SPECIFICALLY TAILORED TO THE CAPABILITIES AND CONSTRAINTS OF THE ATLAS.	FABRICATION CADCAM

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
5	4507	APPLICATION OF CAD TO ACCEPTANCE TEST OF PROD PIEZOIDS	73	125	COMPLETED
			74	125	COMPLETED
			75	129	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
IT IS DIFFICULT TO CONDUCT REPEATABLE ACCEPTANCE TESTING OF PRODUCTION PIEZOIDS.	ESTABLISH ACCEPTANCE CRITERIA MODELS BASED ON FUNCTIONS OF FORCE, TEMPERATURE AND VOLTAGE FOR PREDICTING PIEZOID PERFORMANCE	TEST, INSP, EVAL

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
6	7111	COMPUTER ASSISTED GRAPHICAL TECHNIQUE FOR PROD OF WEA SYS	75	120	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
PRODUCTION ENGINEERING HAS LONG LEAD TIMES.	ESTABLISH COMPUTER ASSISTED INTERACTIVE/GRAPHICAL TECHNIQUES WHICH WILL ENABLE A REDUCTION OF PRODUCTION ENGINEERING LEAD TIMES.	CADCAM INTERACTION

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
6	7248	IMPROVED MFG CONTROL THROUGH DATA AUTOMATION-CAM	73	112	COMPLETED
			74	112	COMPLETED
			75	172	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
SLOW RESPONSE OF PLANNING, ESTIMATING, SCHEDULING AND CONTROLLING OF PRODUCTION FUNCTIONS TO MEET DEMANS OF A REPAIDLY CHANGING MANUFACTURING ENVIRONMENT.	DEVELOP A COMPUTER BASED PRODUCTION PLANNIFG AND CONTROL SYSTEM.	MANUFACTURING CONTROL

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
6	7334	ION BEAM SURFACING OF IR OPTICAL ELEMENTS	74	90	COMPLETED
			76	100	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
FABRICATING AND TESTING INFRARED OPTICS MADE OF NON-GLASS CRYSTALLINE MATERIAL IS EXPENSIVE AND TIME CONSUMING.	ESTABLISH AN IR METROLOGY SYSTEM FOR USE IN THE COMPUTER CONTROLLED OPTICAL FIGURING AND POLISHING FACILITY TO FINISH AND TEST IR OPTICS.	FABRICATION CADCAM

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
6	7455	COMPUTER GENERATED MASTERS FOR GRAPHICAL FIRING TABLES	76	60	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
THE PREPARATION OF MASTER PATTERNS FOR USE IN THE MANUFACTURE OF GRAPHICAL FIRING TABLES IS A TEDIOUS AND DIFFICULT DRAFTING CHORE HIGHLY SUBJECT TO ERROR.	A METHOD OF MASTER PREPARATION USES COMPUTER SOFTWARE AND A HIGH RESOLUTION PLATTER IS TO BE ESTABLISHED.	SIM, MODEL, OP RESCH

SECONDARY CADCAM--COMPLETED PROJECTS
09/20/79

```
***
 COMMAND CODE   PROJ NO   TITLE                                                    FY    COST   CYCLE
***
*     M          9000     IMPROVED PARTS PROGRAMMING NUMERICALLY CONTROLLED MACH   75       8   COMPLETED

 PROBLEM                                       SOLUTION                                               TECHNOLOGY AREA
***
* PARTS PROGRAMMING FOR NUMERICALLY CONTROLLED MACH   INVESTIGATE AND SUMMARIZE THE FIELD OF PARTS PROGR   FABRICATION CADCAM
 INES IS CONSTRAINED BY A LACK OF STANDARDIZATION    AMMING.
 IN NC PROGRAM LANGUAGE.

***
* -----------------------------------------------------------------------------------------------------------------

 COMMAND CODE   PROJ NO   TITLE                                                    FY    COST   CYCLE
***
*     R          3073     MANTECH FOR STATIC SWITCHES                              75     175   COMPLETED
*                                                                                  76     125   COMPLETED

 PROBLEM                                       SOLUTION                                               TECHNOLOGY AREA
***
* CURRENTLY AVAILABLE MECHANICALLY OPERATED SWITCHE   DEVELOP MANUFACTURING TECHNIQUES FOR HIGHLY RELIAB   ASSEMBLY CADCAM
 S DO NOT POSSESS DESIRABLE ELECTRICAL CHARACTERIS   LE LIGHTWEIGHT SOLID STATE SWITCHES.
 TICS.

***
* -----------------------------------------------------------------------------------------------------------------

 COMMAND CODE   PROJ NO   TITLE                                                    FY    COST   CYCLE
***
*     R          3096     MFG PROCESSES FOR LASER TERMINAL HOMING SEEKER           74     450   COMPLETED
*                                                                                  75     275   COMPLETED

 PROBLEM                                       SOLUTION                                               TECHNOLOGY AREA
***
* LASER SEEKERS IN 120-150 LOTS HAS BEEN ESTIMATED   METHODS WHICH USE SIMPLIFIED CONSTRUCTION, INTEGRA   FABRICATION CADCAM
 TO BE $12,000. THIS HIGH COST ARISES FROM THE MUL   TED CIRCUITS AND AUTOMATED PRODUCTION METHODS TO R
 TICOMPONENT CONSTRUCTION AND HAND ASSEMBLY METHOD   EDUCE COST AND WEIGHT WILL BE ESTABLISHED, AND NEW
 S USED INFABRICATING THE SEEKER.                     METHODS FOR MAKING PHOTODETECTORS WITH HIGHER YIE
                                                     LD WILL BE DEVELOPED.

***
* -----------------------------------------------------------------------------------------------------------------
```

SECONDARY CADCAM--COMPLETED PROJECTS
09/20/79

```
***
 COMMAND CODE   PROJ NO   TITLE                                                   FY    COST   CYCLE
***
*      T           4330    FABRICATE ARMOR VEHICLES USING ELECTRON BEAM WELDING PROCESS   74     200   COMPLETED
*                                                                                 75     100   COMPLETED
*                                                                                 76     100   COMPLETED
 PROBLEM                                        SOLUTION                                      TECHNOLOGY AREA
***
* THE INERT GAS (MIG) PROCESS NO LONGER REPRESENTS   ESTABLISH THE FEASIBILITY OF THE EB WELDING PROCES   FABRICATION CADCAM
  THE BEST METHOD OF WELDING ALUMINUM ARMORED VEHIC  S.
  LES.

***
* -----------------------------------------------------------------------------------------------------
 COMMAND CODE   PROJ NO   TITLE                                                   FY    COST   CYCLE
***
*      T           4512    AUTOMATED WELDING OF HULL STRUCTURES- MORE THAN ONE AXIS        74     200   COMPLETED
*                                                                                 75     117   COMPLETED
 PROBLEM                                        SOLUTION                                      TECHNOLOGY AREA
***
* PRESENT METHODS FOR THE MANUFACTURE OF VEHICLE HU  AUTOMATE THE WELDING AND POSITIONING OF THE HULL S   FABRICATION CADCAM
  LL STRUCTURES UTILIZING GAS METAL ARC WELDING ARE  TRUCTURE.
   EXTREMELY TIME CONSUMING.

***
* -----------------------------------------------------------------------------------------------------
 COMMAND CODE   PROJ NO   TITLE                                                   FY    COST   CYCLE
***
*      1           7103    BLISK AND IMPELLER MFG BY AUTOMATIC MULTI SPINDLE MACHINING     76     435   COMPLETED
*                                                                                 77     305   COMPLETED
 PROBLEM                                        SOLUTION                                      TECHNOLOGY AREA
***
* INTEGRAL BLADES DISKS, AND IMPELLERS, WHEN MANUFA  DEVELOP THE PROCESS TO MANUFACTURE THESE COMPONENT   FABRICATION CADCAM
  CTURED BY SINGLE SPINDLE TRACING EQUIPMENT, ARE E  S BY ONE OF SEVERAL ROUGHING METHODS, FINISH MILLI
  XPENSIVE                                           NG BY NUMERICALLY CONTROLLED MULTI SPINDLE MACHINE
                                                     S AND ABRASIVE FLOW FINISHING.

***
* -----------------------------------------------------------------------------------------------------
```

SECONDARY CADCAM--COMPLETED PROJECTS
09/20/79

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
5	1277	FAST RESPONSE CONTAMINANT MONITORS FOR INDUSTRIAL OPERATION	73	197	COMPLETED
			74	501	COMPLETED
			75	988	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
THERE IS A NEED FOR CONTAMINANT MONITORS FOR INDUSTRIAL PLANT OPERATIONS.	FABRICATE AND EVALUATE A PROTOTYPE MONITORING WITH HIGH SENSITIVITY AND A FAST RESPONSE TIMER.	TEST, INSP, EVAL

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
5	3139	MFG OF INTERCONNECTIONS FOR FLUIDIC CIRCUITS	76	145	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
INVESTIGATE HOW COMPUTER-AIDED TECHNIQUES NOW BEING DEVELOPED CAN BE APPLIED TO PRODUCTION OF FLUIDIC INTERCONNECTIONS.	INVESTIGATE TECHNICAL DETAILS ABOUT EACH OF FIVE PRODUCTION BONDING PROCESSES USSING RIDGE SEALS.	CADCAM INTERACTION

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
5	4284	PROGRAMABLE FLUIDIC CONTROL SYSTEM FOR LAP MACHINERY	76	160	COMPLETED

PROBLEM	SOLUTION	TECHNOLOGY AREA
NEED TO PROVIDE ENGINEERING EFFORT TO INCORPORATE MODERN FLUIDIC CONTROL TECHNIQUES INTO A WIDE RANGE OF LAP EQUIPMENT.	EFFORTS DIRECTED TOWARD EVALUATION OF AVAILABLE FLUIDIC SYSTEMS AND COMPONENTS AND PREPARING A HANDBOOK TO BE USED IN THE PREPARATION OF SCOPES OF WORK AND CONTRAACT AWARDS FOR UNITS OF A PROTOTYPE SYSTEM.	MANUFACTURING CONTROL

SECONDARY CADCAM--COMPLETED PROJECTS
09/20/79

```
***
  COMMAND CODE   PROJ NO   TITLE                                                             FY    COST   CYCLE
***
*      5           4456    COMPUTERIZED MATERIALS PROPERTY DATA INFORMATION SYSTEM            76     100   COMPLETED
  PROBLEM                                          SOLUTION                                                  TECHNOLOGY AREA
***
* THERE IS NO RAPID ACCESS TO INFORMATION IN SUPPOR   COMPUTERIZE APPROPRIATE MATERIAL PROPERTY AND PROC   DATA BASE/DATA AUTOMATION
  T OF ARMY PRODUCTION ENGINEERING FUNCTIONS.         ESSIBILITY DATA AS RELATED TO THE MANY MANUFACTURI
                                                      NG PROCESSES.

***
* ----------------------------------------------------------------------------------------------------------------
  COMMAND CODE   PROJ NO   TITLE                                                             FY    COST   CYCLE
***
*      5           4500    MOD TEST TECH FOR IMMED DATA ACQ,RED,ANLAND DISSEM,CAM RELAT       73     425   COMPLETED
*                                                                                             74     450   COMPLETED
*                                                                                             75     190   COMPLETED
*                                                                                             76     188   COMPLETED
  PROBLEM                                          SOLUTION                                                  TECHNOLOGY AREA
***
* WHERE MANUAL DATA REDUCTION TECHNIQUES ARE EMPLOY   DEVELOP AND IMPLEMENT AN AUTOMATED SYSTEM CAPABLE    TEST, INSP, EVAL
  ED, THE REDUCTION AND PERFORMANCE ANALYSIS IS TIM   OF REAL-TIME ANALOG OR DIGITAL RAW TEST DATA ACQUI
  E CONSUMING, REQUIRES HIGHLY SKILLED PROFESSIONAL   SITION AND REDUCTION.
  S, AND IS SUSCEPTIBLE TO HUMAN ERROR, SUBJECTIVIT
  Y, AND OMISSION.

***
* ----------------------------------------------------------------------------------------------------------------
```

APPENDIX E

CAM MMT EFFORTS ACTIVE

This appendix contains a listing of CAM related MMT efforts currently active. Data presented on each effort includes the MMT effort number, command code, title, MMT effort FY, cost, a statement of the problem, a statement of the solution, and the technology area into which the effort is categorized. Data is displayed in two separate lists. The first list consists of those efforts where CAM is identified as a primary function. The second list consists of those efforts where CAM is identified as a secondary function.

Refer to Appendix D for "explanation of data presentation."

PRIMARY CADCAM--ACTIVE PROJECTS
09/20/79

```
***
  COMMAND CODE   PROJ NO   TITLE                                                  FY    COST   CYCLE
***
*       F         9679     NUMERICAL CONTROL LATHE LANGUAGE EVALUATION            72     225   COMPLETED
*                                                                                 76     395   APPROVED

  PROBLEM                                      SOLUTION                                        TECHNOLOGY AREA
***
* THERE ARE APPROXIMATELY 17 MAJOR NUMERICAL CONTRO   EVALUATE EACH LANGUAGE AND ITS ADVANTAGES AND DISA   FABRICATION CADCAM
  L LATHE LANGUAGES CURRENTLY IN POPULAR USE.         DVANTAGES FOR SPECIFIC LATHE OPERATIONS.

***
* ----------------------------------------------------------------------------------------------------------------

  COMMAND CODE   PROJ NO   TITLE                                                  FY    COST   CYCLE
***
*       M         9811     REDUCTION OF MFG COSTS FOR NW POWER XISTORS + IN-PROC TUNING   77     597   APPROVED

  PROBLEM                                      SOLUTION                                        TECHNOLOGY AREA
***
* POWER TRANSISTORS REQUIRE SCORES OF INTERNAL INTE   DEVELOP EQUIPMENT AND PROCEDURES FOR AUTOMATIC ATT   FABRICATION CADCAM
  RCONNECTIONS, NOW BEING APPLIED BY HAND.            ACHMENT OF INTERNAL LEADS AND POWER BALANCING COMP
                                                      ONENTS.

***
* ----------------------------------------------------------------------------------------------------------------

  COMMAND CODE   PROJ NO   TITLE                                                  FY    COST   CYCLE
***
*       M         9845     NUMERICALLY CONTROLLED OPTICAL FABRICATION             77     333   APPROVED
*                                                                                 81     518   BUDGET

  PROBLEM                                      SOLUTION                                        TECHNOLOGY AREA
***
* ASPHERIC LENSES REQUIRED BY FLIR SENSORS HAVE SEV   PROVIDE MFG. METHODS FR PRODUCING ASPHERICAL FLIR    FABRICATION CADCAM
  ERE WEIGHT AND SIZE LIMITIATIONS AND ARE DIFFICUL   LENS USING A SINGLE POINT DIAMOND TURNING LATHE IN
  T TO MFG. BECAUSE OF THE REPETITIVE PROCESS OF SU   TEGRATED WITH COMPUTER CONTROLLS AND LASER INTERFE
  RFACE SHAPING.                                      RMETRIC FEEDBACK OF CUTTING TOOL POSITIONS.

***
* ----------------------------------------------------------------------------------------------------------------
```

PRIMARY CADCAM--ACTIVE PROJECTS
09/20/79

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
Q	8036	NUMERICALLY CONTROLLED HELMET DIE SINKING	74	70	COMPLETED
			76	75	APPROVED

PROBLEM	SOLUTION	TECHNOLOGY AREA
CURRENT HELMETS ARE NOT MANUFACTURED BY TRANSLATING ENGINEERED HELMET SHAPES INTO NC TAPES SUITABLE FOR PRODUCING HELMET MOLDS.	ESTABLISH TECHNIQUES TO TRANSLATE ENGINEERED HELMET SHAPES INTO NC TAPES SUITABLE FOR PRODUCING HELMET MOLDS.	CADCAM INTERACTION

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
Q	8053	CAD/CAM FOR MANUFACTURE OF 3-DIMENSIONAL FORMS AND DIES	77	253	APPROVED

PROBLEM	SOLUTION	TECHNOLOGY AREA
THE PRODUCTION BASE FOR SMALL HARDWARE ACCESSORIES, PRINCIPALLY FORGING, FOR PARACHUTES IS LIMITED AND DEPENDS ON HIGHLY SKILLED DIE AND MOLD MAKERS.	DEVELOP AND USE COMPUTER AIDED MANUFACTURING TECHNIQUES FOR PROCUREMENT OF SMALL HARDWARE PARTS, INCLUDING THE DIE AND MOLD MANUFACTURE.	CADCAM INTERACTION

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
R	3091	AUTOMATIC AFFIXING OF ELECTRICAL CONNECTORS TO CABLES	77	150	COMPLETED
			74	156	COMPLETED
			76	250	COMPLETED
			77	140	APPROVED

PROBLEM	SOLUTION	TECHNOLOGY AREA
INTERCONNECTING CABLES AND NETWORKS ARE SUBJECT TO HUMAN ERROR IN THE ATTACHMENT OF CONNECTORS TO CABLES, WITH HIGH FAILURE PERCENTAGES COMMONPLACE.	DEVELOP AUTOMATED TECHNIQUES TO ATTACH ELECTRIC CONNECTORS TO THE CABLE.	ASSEMBLY CADCAM

```
***
  COMMAND CODE   PROJ NO   TITLE                                                        FY    COST   CYCLE
***
*      R           3169     AUTO OPTICAL INSPECTION OF PC BOARDS + COMPONENTS(CAM)        77    275    APPROVED

  PROBLEM                                          SOLUTION                                             TECHNOLOGY AREA
***
* OPERATOR FATIGUE ALLOWS MANY BAD PCB#S TO PASS VI   PROVIDE AN AUTOMATED OPTICAL COMPARATOR TO ELIMINA   CONTINUOUS FLOW PROCESS
  SUAL INSPECTION.                                    TE THE NEED FOR HUMAN INSPECTOR.

***
* ----------------------------------------------------------------------------------------------------------------------

  COMMAND CODE   PROJ NO   TITLE                                                        FY    COST   CYCLE
***
*      R           3268     AUTOMATIC CONTROL OF PLATING                                   78    450    APPROVED
*                                                                                          79    450    APPROVED

  PROBLEM                                          SOLUTION                                             TECHNOLOGY AREA
***
* THE BATHS USED FOR PLATING PRINTED WIRING BOARDS    DEVELOP CENTRALIZED CONTROLLER SYSTEM WHICH WILL S   FABRICATION CADCAM
  HAVE AN EXTREMELY LARGE NUMBER OF VARIABLES WHICH   ENSE MULTIPLE INPUTS, KEEPING PROCESS PARAMETERS I
   INFLUENCE PCB QUALITY. IF ANY VARIABLE DRIFTS OU   N BALANCE.
  T OF RELATIVELY NAROW BOUNDS, IMPAIRED QUALITY RE
  SULTS.

***
* ----------------------------------------------------------------------------------------------------------------------

  COMMAND CODE   PROJ NO   TITLE                                                        FY    COST   CYCLE
***
*      T           5014     FOUNDRY CASTING PROCESSES USING FLUID FLOW + THERM ANALYS      77    560    APPROVED
*                                                                                          78    415    APPROVED

  PROBLEM                                          SOLUTION                                             TECHNOLOGY AREA
***
* FOUNDRY CASTING PROCESSES ARE WASTEFUL OF RAW MAT   OPTIMIZE CASTING PROCESSES BY DIGITAL COMPUTER ANA   CADCAM INTERACTION
  ERIALS AND ENERGY.                                  LYSIS OF ADVANCED FLUID FLOW AND THERMAL ACTIVITY.

***
* ----------------------------------------------------------------------------------------------------------------------
```

PRIMARY CADCAM--ACTIVE PROJECTS
09/20/79

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
1	5024	GEAR DIE DESIGN AND MFG UTILIZING COMPUTER TECHNOLOGY (CAM)	78	200	APPROVED
			79	205	APPROVED
			81	350	BUDGET

PROBLEM	SOLUTION	TECHNOLOGY AREA
THE CONTROL OF DIMENSIONAL TOLERANCES OF FORGED BEVEL GEARS PRESENTS A UNIQUE PROBLEM SINCE THESE GEARS ARE NOT MFG. TO THEORETICAL EQUATIONS. THE BEVEL GEAR IS NOT DEFINED DIMENSIONALLY BUT IS PRESENTED AS REQUIREMENTS FOR TOOTH BEARING PATTER*	THIS PROGRAM WILL ELIMINATE THE CURRENT TRIAL AND ERROR METHODS BY UTILIZING CADCAM METHODS AND INTERACTIVE GRAPHICS TECHNIQUES. EXCESSIVE SCRAP, UNEXPECTED DIE WEAR AND BREAKAGE, AND THE HIGH COST OF FORGING DIES WILL BE ADDRESSED.	CADCAM INTERACTIOP

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
1	5082	FLEXIBLE MACHINING SYSTEM PILOT LINE FOR TCV COMPONENT	79	440	APPROVED
			80	880	APPORTIONMENT
			81	880	BUDGET

PROBLEM	SOLUTION	TECHNOLOGY AREA
PARTS FOR TRACKED COMBAT VEHICLES ARE TYPICALLY NOT MANUFACTURED IN LARGE QUANTITIES. BECAUSE OF THIS, MASS PDN TECHNOLOGIES THAT RESULT IN LOWER PDN COSTS ARE NOT USED.	THE ADVANTAGES OF MASS PDN CAN BE REALIZED IN PRODUCING MEDIUM QUANTITY SIZE LOTS BY A CONCEPT KNOWN AS, FLEXIBLE MACHINING SYSTEMS. THIS PROJECT WILL ADVANCE THE FMS TECHNOLOGY MAKING IT FEASIBLE TO UTILIZE FMS FOR THE MFG OF ARMY MATERIEL.	FABRICATION CADCAM

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
1	7123	IN PROCESS TECHNIKS FOR CONTINUOUS BALANCING HELI SHAFTING	78	105	APPROVED

PROBLEM	SOLUTION	TECHNOLOGY AREA
EXISTING BALANCING TECHNIQUES FOR SHAFTING ARE DIFFICULT AND COSTLY, REQUIRING MANY TRIAL SPEED RUNS TO ESTABLISH THE PROPER BALANCE.	DEVELOP AN IN-PROCESS, COMPUTER-AIDED TECHNIQUE FOR CONTINUOUS BALANCING OF SHAFTS THAT REQUIRES ONLY SLOW, NEARLY STATIC ROTATION OF THE SHAFT.	FABRICATION CADCAM

PRIMARY CAUCAM--ACTIVE PROJECTS
09/20/79

```
***
  COMMAND CODE   PROJ NO   TITLE                                                           FY    COST   CYCLF
***
*     4           4568     TECHNICAL DATA/CONFIGURATION MANAGEMENT SYSTEM                   7T    500    APPROVED
*                                                                                            74    100    COMPLETED
*                                                                                            75    220    COMPLETED

  PROBLEM                                           SOLUTION                                              TECHNOLOGY AREA
***
* THERE IS NO STANDARD TD/CMS.                      DEVELOP A DARCOM WIDE STANDARD TD/CMS AND IMPROVED    DATA BASE/DATA AUTOMATION
                                                     TECHNICAL DATA PACKAGES.

***
* ----------------------------------------------------------------------------------------------------------------------

  COMMAND CODE   PROJ NO   TITLE                                                           FY    COST   CYCLE
***
*     5           4322     DES CRIT/SYS CHAR OF FLEC CONTROL PROD FAC                       78    185    APPROVED
*                                                                                            79    610    APPROVED
*                                                                                            80    515    APPORTIONMENT

  PROBLEM                                           SOLUTION                                              TECHNOLOGY AREA
***
* UNCERTAINTY OF THE EFFECT OF LONG TERM STORAGE DU  ANALIZE DATA CONCERNING DEGRADATION OF ELECTRONIC    MANUFACTURING CONTROL
  RING PLANT LAYAWAY ON ELECTRONIC CONTROL SYSTEMS   SYSTEMS DURING PERIODS OF DORMANCY AND DEVELOP CRI
  AND THE ASSOCIATED IMPACT ON PRODUCTION BASE LEAD  TERIA FOR LAYAWAY PLANNING AND FUTURE SYSTEM DESIG
   TIME.                                             N.

***
* ----------------------------------------------------------------------------------------------------------------------

  COMMAND CODE   PROJ NO   TITLE                                                           FY    COST   CYCLF
***
*     5           6736     TECH READINESS ACCEL THRU COMPUTE INTEGRATED MFG (TRACIM)        76     40    COMPLETED
*                                                                                            78    100    APPROVED
*                                                                                            79    256    APPROVED
*                                                                                            80    290    APPORTIONMENT

  PROBLEM                                           SOLUTION                                              TECHNOLOGY AREA
***
* THE LEAD TIME REQUIRED TO BRING PRODUCTION LINES   THE DEVELOPMENT AND IMPLEMENTATION OF A COMPUTER I   ARCHITECTURE
  TO MOBILIZATION MAXIMUM IS INTOLERABLY EXCESSIVE.  NIEGRATED MANUFACTURING SYSTEM WILL SIGNIFICANTLY
   A CRITICAL DETERRENT IS THE EXTREME SHORTAGE OF   REDUCE THE REQUIREMENT FOR HIGHLY SKILLED CRAFTSME
  TOOLMAKERS AND MACHINISTS.                         N.

***
* ----------------------------------------------------------------------------------------------------------------------
```

PRIMARY CADCAM--ACTIVE PROJECTS
09/20/79

```
***
 COMMAND CODE   PROJ NO   TITLE                                                                          FY     COST   CYCLE
***
*      6          7580    PILOT AUTO SHOP LOADING AND CONTROL SYSTEM-CAM                                 75      260   COMPLETED
*                                                                                                        76      350   APPROVED
 PROBLEM                                                  SOLUTION                                                      TECHNOLOGY AREA
***
* A MORE EFFECTIVE SYSTEM IS REQUIRED FOR SHOP LOAD       INSTALL A COMPUTERIZED SYSTEM FOR CONTROL OF PRODU          MANUFACTURING CONTROL
  ING AND CONTROL OF PRODUCTION. THE SYSTEM SHOULD        CTION SCHEDULING OF SHOP ORDERS. CURRENT STATUS IN
  BE MORE RESPONSIVE TO SCHEDULE CHANGES.                 FORMATION WILL BE AVAILABLE THRU RANDOM ACCESS. EM
                                                          PLOY PRIORITY SEQUENCING.
***
* ------------------------------------------------------------------------------------------------------------------------------------

 COMMAND CODE   PROJ NO   TITLE                                                                          FY     COST   CYCLE
***
*      6          7649    COMPUTERIZED POWDER METALLURGY FORGING DESIGN-CAM                              77      100   COMPLETED
*                                                                                                        78      102   APPROVED
 PROBLEM                                                  SOLUTION                                                      TECHNOLOGY AREA
***
* IN THE OVERALL PROCESS DESIGN FOR P/M FORGING, PR       COMPUTER ANALYSIS OF STRESSES AND FLOW PATTERNS AN          CADCAM INTERACTION
  EFORM DESIGN IS MOST DIFFICULT AND RELIES ON A TR       D COMPUTER GRAPHIC TECHNIQUES WILL AID IN PREFORM
  IAL-AND-ERROR APPROACH.                                 DESIGN.
***
* ------------------------------------------------------------------------------------------------------------------------------------

 COMMAND CODE   PROJ NO   TITLE                                                                          FY     COST   CYCLE
***
*      6          7707    AUTOMATED PROCESS CONTROL FOR MACHINING (CAM)                                  77      105   APPROVED
*                                                                                                        79       95   BUDGET
*                                                                                                        80      114   APPORTIONMENT
 PROBLEM                                                  SOLUTION                                                      TECHNOLOGY AREA
***
* MACHINING OPERATIONS ARE SELECTED, PARAMETERS ARE       APPLY COMPUTERIZED CONTROLS FOR OVERALL SELECTION           MANUFACTURING CONTROL
  SET, AND STANDARDS ARE ESTABLISHED EMPIRICALLY W        OF PROCESSES, OPERATIONS, PARAMETERS, FEEDBACK AND
  ITH LITTLE OR NO ENGINEERING ANALYSES, CONTROL OR        OPTIMATION, WITH AUTOMATED ESTIMATING AND DETERMI
  FEEDBACK.                                               NATION OF REAL TIME AND COSTS.
***
* ------------------------------------------------------------------------------------------------------------------------------------
```

PRIMARY CADCAM--ACTIVE PROJECTS
09/20/79

```
***
COMMAND CODE   PROJ NO   TITLE                                                          FY    COST   CYCLE
***
*      6         7714    MULTI-MODE WEAPON- MOUNT IMPEDANCE SIMULATOR-CAM              77     285   APPROVED

PROBLEM                                          SOLUTION                                                 TECHNOLOGY AREA
***
* PRESENT TEST METHODS DO NOT COMPENSATE FOR VARIOU  BUILD A SIMULATOR CAPABLE OF VARIABLE WEAPON-MOUNT   SIM, MODEL, OP RESCH
  S MEASURES AND FOR MULTIPLE MODES OF VIBRATION OF   IMPEDANCE AND OF SEVERAL EXCITABLE MODES OF VIBRA
  WEAPON MOUNTS.                                     TION.

***
* ---------------------------------------------------------------------------------------------------------------------

COMMAND CODE   PROJ NO   TITLE                                                          FY    COST   CYCLE
***
*      6         7724    GROUP TECHNOLOGY OF WEAPON SYSTEMS                            79      83   APPROVED
*                                                                                      81     224   BUDGET

PROBLEM                                          SOLUTION                                                 TECHNOLOGY AREA
***
* THERE IS A NEED TO REDUCE AND CONTROL THE PROLIFE  THE ARMY HAS PURCHASED A GROUP CLASSIFICATION AND    PLANNING/GROUP TECH
  RATION OF PARTS AND DESIGNS FORITEMS MANUFACTURED  CODING SOFTWARE PACKAGE. ONCE THIS SYSTEM IS IMPLE
  AT WATERVLIET ARSENAL.                             MENTED, IT SHOULD BE POSSIBLE TO REDUCE THE NUMBER
                                                     OF DIFFERENT PARTS THRU STANDARDIZATION.

***
* ---------------------------------------------------------------------------------------------------------------------

COMMAND CODE   PROJ NO   TITLE                                                          FY    COST   CYCLE
***
*      6         7807    PROGRAMMED OPTICAL SURFACING EQUIP AND METHODOLOGY-CAM        78     134   APPROVED
*                                                                                      79     138   APPROVED
*                                                                                      80     123   BUDGET
*                                                                                      81     126   BUDGET

PROBLEM                                          SOLUTION                                                 TECHNOLOGY AREA
***
* CURRENT TECHNIQUES FOR PITCH BUTTONING AND BLOCKI  ADOPT COMPUTER TECHNIQUES AND INSTRUMENTATION WITH   FABRICATION CADCAM
  NG PRECISION LENSES USE OLDER CONVENTIONAL EQUIP.   CONTROLS TO PITCH BUTTONING AND BLOCKING OPERATIO
  ACCURACY DEPENDS ON THE SKILL AND EXPERIENCE OF    NS. THE END PRODUCT WILL BE AN INTEGRATED SURFACIN
  WELL TRAINED MASTER OPTICIANS WHO ARE BECOMING SC  G SYSTEM IMPLEMENTED IN THE FIRE CONTROL FABRICATI
  ARCE.                                              ON FACILITY AT ARRADCOM.

***
* ---------------------------------------------------------------------------------------------------------------------
```

PRIMARY CADCAM--ACTIVE PROJECTS
09/20/79

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
6	7949	APPLICATION OF GROUP TECHNOLOGY MANUFACTURING (CAM)	79	127	APPROVED
			80	155	APPORTIONMENT

PROBLEM	SOLUTION	TECHNOLOGY AREA
PRESENT PLANNING, SCHEDULING, AND MANUFACTURE OF WEAPON ASSEMBLIES AND COMPONENTS ARE BY SEPARATE LOTS AND PARTS WHICH REQUIRE MULTIPLE, MACHINING OPERATIONS, SET-UPS AND CHANGES OF TOOLING, AND CAUSE LOSS OF TIME AND MONEY.	APPLY GROUP TECHNOLOGY TO CLASSIFY, CODE AND MANUFACTURE WEAPON ASSEMBLIES AND COMPONENTS AS FAMILIES-OF-PARTS, MATCH PARTS BY CONTOUR AND SIZE FOR SIMULTANEOUS MACHINING- AND, SUB-GROUP FOR MORE EFFICIENT MACHINING AND ASSEMBLY.	PLANNING/GROUP TECH

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
6	7963	GROUP TECH + CELLULAR MFG FOR FIRE COMPONENTS + ASSEMBLIES	79	188	APPROVED
			80	303	APPORTIONMENT

PROBLEM	SOLUTION	TECHNOLOGY AREA
FIRE CONTROL MANUFACTURING HAS RESULTED IN THE PROLIFERATION OF MANUFACTURING INFORMATION, LONG SET-UP TIMES OR MULTIPLE RESETTING OF MACHINES, UNDER-UTILIZATION OF MACHINES, LONG AND UNCERTAIN THROUGHPUT TIMES, AND HIGH WORK-IN PROGRESS.	THROUGH GROUP TECHNOLOGY PART FAMILIES, MACHINE GROUPS, TOOL GROUPS AND WORK GROUPS WILL BE ESTABLISHED TO REALIZE THE FOLLOWING - REDUCED PLANNING EFFORT, SET-UP TIME, WORK-IN PROGRESS, LEVEL OF SCRAP AND MORE EFFECTIVE MACHINE OPERATIONS.	PLANNING/GROUP TECH

SECONDARY CAUCAM--ACTIVE PROJECTS
09/20/79

```
***
  COMMAND CODE   PROJ NO   TITLE                                                        FY     COST   CYCLE
***
*      F          9773     COMPUTER AID F/PREP OF AUTO ANALOG CIRCUIT PROON TEST PROG   76     186    COMPLETED
*                                                                                       78     500    APPROVED

  PROBLEM                                          SOLUTION                                           TECHNOLOGY AREA
***
* INDUSTRY DOES NOT POSSESS PROGRAMS TO VALIDATE TH   PREPARE A TESTING PROGRAM THAT WILL VALIDATE AND E   TEST, INSP, EVAL
  E TEST PROGRAMS REQUIRED TO TEST ANALOG CIRCUITS.   VALUATE ANALOG TEST PURGRAMS.

***
* ----------------------------------------------------------------------------------------------------------------------
  COMMAND CODE   PROJ NO   TITLE                                                        FY     COST   CYCLE
***
*      F          9938     LED MATRIX MODULE                                            79     510    APPROVED

  PROBLEM                                          SOLUTION                                           TECHNOLOGY AREA
***
* PRESENT MANUFACTURING METHODS ARE TOO COSTLY AND    ESTABLISH NEW FABRICATION AND HANDLING TECHNIQUES    FABRICATION CAUCAM
  COMPLICATED SINCE MANY COMPONENTS HAVE TO BE INTE   TO REDUCE COSTS AND STILL PROVIDE A RELIABLE MODUL
  RCONNECTED AND MOUNTED BY HAND.                     E.

***
* ----------------------------------------------------------------------------------------------------------------------
  COMMAND CODE   PROJ NO   TITLE                                                        FY     COST   CYCLE
***
*      H          9808     AUTO INPROCESS EVAL OF THICK FILM PRINT + HYBRID CKT ASSY    77     576    APPROVED

  PROBLEM                                          SOLUTION                                           TECHNOLOGY AREA
***
* DEFECTS CAN OCCUR IN SCREENED CIRCUIT PATTERNS WH   DEVELOP A TV TYPE SCANNER TO LOOK AT A SCREENED OR   TEST, INSP, EVAL
  ILE THEY ARE BEING SCREENED ONTO THE CERAMIC BASE    COMPLETED BOARD AND COMPARE THE PICTURE ON A BIT-
  . ALSO, COMPONENTS CAN BE ASSEMBLED ONTO THE BOAR   BY-BIT BASIS WITH A GOOD BOARD. USE A MINI-COMPUTE
  D INCORRECTLY.                                      R TO ANALYZE DIGITIZED INPUT.

***
* ----------------------------------------------------------------------------------------------------------------------
```

```
***
   COMMAND CODE   PROJ NO   TITLE                                                          FY    COST   CYCLE
***
*       H          9844     PDN OF SILICON ON SAPPHIRE HI SPD ANLOG MULTIPLXER CIRCUITS    79    700    APPROVED

   PROBLEM                                         SOLUTION                                             TECHNOLOGY AREA
***
* SAPPHIRE WAFERS ARE PRODUCED BY THE CONVENTIONAL  THIS PROJECT WILL ESTABLISH THE PRODUCTION CAPABIL  TEST, INSP, EVAL
  GROWN BOULE METHOD. THIS APPROACH IS TIME CONSUMI  ITY FOR THE GROWING OF MULTIPLE RIBBON SAPPHIRE, A
  NG AND COSTLY.                                    ND FOR FABRICATING SILICON ON SAPPHIRE COMPLEMENTA
                                                    RY METAL OXIDE SEMICONDUCTOR MONOLITHIC CIRCUITS.
***
* -----------------------------------------------------------------------------------------------------------------------

   COMMAND CODE   PROJ NO   TITLE                                                          FY    COST   CYCLE
***
*       H          9873     ANTENNA PATTERN MEASUREMENTS USING NEARFIELD TECHNIQUES        77    542    APPROVED

   PROBLEM                                         SOLUTION                                             TECHNOLOGY AREA
***
* PHASED ARRAY ANTENNA TRANSMISSION AND RECEIVING P  USE AUTOMATIC NEAR-FIELD MEASUREMENT UTILIZING A P  TEST, INSP, EVAL
  ATTERNS ARE DETERMINED BY THE INDIVIDUAL ELEMENTS  ROBE NEAR THE ANTENNA, APPLY OUTPUT TO A COMPUTER
  . TESTING THE PATTERN OF A 6,000 ELEMENT ANTENNA  FOR PROCESSING. DEVELOP PERFORMANCE MAP FOR QC DOC
  IS LENGTHY AND COSTLY.                            UMENTATION.
***
* -----------------------------------------------------------------------------------------------------------------------

   COMMAND CODE   PROJ NO   TITLE                                                          FY    COST   CYCLE
***
*       H          9963     LOW COST E-BEAM EQUIPMENT                                      79    1027   APPROVED

   PROBLEM                                         SOLUTION                                             TECHNOLOGY AREA
***
* ELECTRON BEAM PHOTOLITHOGRAPHY IS NEEDED FOR DEFI  DEVELOP A LOWER COST E-BEAM EXPOSURE MACHINE SUITE  CADCAM INTERACTION
  NING ARTWORK, PHOTO-MASKS, OR DIRECT EXPOSURE ON  D TO LOW VOLUME MILITARY APPLICATIONS, RETAIN THE
  A WAFER WHERE CLOSE DEFINITION IS ESSENTIAL. IT I  1/4 MICROMETER RESOLUTION AND HIGH REGISTRATION CA
  S COSTLY BECAUSE PRESENT EQUIPMENT IS DESIGNED FO  PABILITY.
  R LARGE AREA EXPOSURE AND HIGH THROUGHPUT.
***
* -----------------------------------------------------------------------------------------------------------------------
```

SECONDARY CADCAM--ACTIVE PROJECTS
09/20/79

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
R	3171	AUTO MONITOR AND CONTROL FOR WAVE SOLDERING MACHINES	78	454	APPROVED
			79	454	BUDGET

PROBLEM	SOLUTION	TECHNOLOGY AREA
3-5(OF REJECTED PCB#S ARE DUE TO IMPROPER OR UNCONTROLLED WAVE SOLDERING.	DEVELOP AN AUTOMATIC CLOSED LOOP SYSTEM TO MONITOR VARIOUS PARAMETERS TO MAKE IMMEDIATE ADJUSTMENTS TO THE WAVE SOLDER MACHINE.	FABRICATION CADCAM

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
R	3242	DIGITAL FAULT ISOLATION OF PRINTED CIRCUIT BOARDS	78	425	APPROVED
			79	425	APPROVED

PROBLEM	SOLUTION	TECHNOLOGY AREA
LOGICAL CIRCUIT BOARDS EMPLOYED IN MISSILES CAN FAIL IN A NUMBER OF DIFFERENT PLACES. IT IS A SLOW PROCESS TO ISOLATE THE FAULT TO THE DEFECTIVE ELEMENT.	THIS PROJECT WILL DEVELOP FAULT ISOLATION PROCEDURES APPLICABLE DURING CIRCUIT BOARD TEST TO ISOLATE FAULTS DOWN TO THE SMALLEST CIRCUIT PACKAGE ON THE BOARD. THE PROBE TRACE METHOD FOR FAULT ISOLATION WILL BE UTILIZED.	TEST, INSP, EVAL

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
R	3441	APPLICATION OF HIGH ENERGY LASER MANUFACTURING PROCESSES	78	490	COMPLETED
			79	400	APPROVED

PROBLEM	SOLUTION	TECHNOLOGY AREA
COST IS A CRITICAL FACTOR IN CONVENTIONAL WELDING ASSOCIATED WITH O E MANUFACTURE OF HIGH VOLUME MISSILE SYSTEMS SUCH AS CONTAINERS, LAUNCHERS, ETC. THE IMPLEMENTATION OF LASER PROCESSES HAS THE POTENTIAL FOR ENORMOUS COST SAVINGS.	INTEGRATE HIGH ENERGY LASER TECHNOLOGY AND COMPUTER AIDED MANUFACTURING CONTROLS INTO SYSTEMS CAPABLE OF HIGH PRODUCTION RATES AND MINIMAL COSTS.	FABRICATION CADCAM

```
                         SECONDARY CADCAM--ACTIVE PROJECTS
                                    09/20/79

***
 COMMAND CODE  PROJ NO   TITLE                                                     FY    COST   CYCLE
***
*    1          7144     TURBINE ENGINE NOZZLE IN PROCESS INSPECTION               77      74   APPROVED
*                                                                                  78      67   APPROVED

 PROBLEM                                            SOLUTION                                    TECHNOLOGY AREA
***
* ASSEMBLED TURBINE NOZZLES NEED INSPECTION AND CHE  DEVELOP AND USE AN AUTOMATIC IN-PROCESS NON-DESTRU  TEST, INSP, EVAL
  CK FOR BLOCKAGE AND AIR FLOW VOLUME.               CTIVE TEST PROCEDURE FOR CHECKING NOZZLES FOR OBST
                                                     RUCTIONS AND ADEQUATE AIR FLOW.

***
* ------------------------------------------------------------------------------------------------------------

 COMMAND CODE  PROJ NO   TITLE                                                     FY    COST   CYCLE
***
*    5          3961     IMPROVE (3-D) VIBRATION ACCEPT TEST F/M732 M724           79     282   APPROVED
*                                                                                  80     605   APPORTIONMENT
 PROBLEM                                            SOLUTION                                    TECHNOLOGY AREA
***
* CURRENT METHODS ARE COSTLY AND TIME CONSUMING, RA  USE OF COMPUTERIZED 3-D VIBRATION / SHOCK TESTING  TEST, INSP, EVAL
  RELY EXPOSE THE TEST ITEM TO TRUE SERVICE ENVIRON  AS AN ACCEPTANCE TOOL SOLVES TECHNICAL + ECONOMIC
  MENTS, AND REQUIRE THREE TESTS TO ACCOUNT FOR ALL  TEST DEFICIENCIES, TEST TIME IS REDUCED
   TEST AXES.

***
* ------------------------------------------------------------------------------------------------------------

 COMMAND CODE  PROJ NO   TITLE                                                     FY    COST   CYCLE
***
*    5          4105     AUTO INCREMENT LOAD + ASSY OF PROP CHRG W/CTR CORE IGNITER  7T     225   COMPLETED
*                                                                                  73     105   COMPLETED
*                                                                                  74     477   COMPLETED
*                                                                                  75     525   COMPLETED
*                                                                                  76     685   COMPLETED
*                                                                                  77    1385   APPROVED
 PROBLEM                                            SOLUTION                                    TECHNOLOGY AREA
***
* ALL PROP CHGS W/CENTER CORE IGNIFRS ARE LOADED MA  DESIGN, FABRICATE AND PROVE-OUT MACHINERY TO AUTOM  ASSEMBLY CADCAM
  NUALLY AND HAVE HIGH LABOR COSTS, AND PERSONNEL E  OMATICALLY PROP CHARGES.
  XPOSURE.

***
* ------------------------------------------------------------------------------------------------------------
```

SECONDARY CADCAM--ACTIVE PROJECTS
09/20/79

```
***
COMMAND CODE   PROJ NO   TITLE                                                     FY    COST   CYCLE
***
*    5          4124     FABRICATION OF CONTROL ACTUATION SYSTEM HOUSINGS          79     930   APPROVED

PROBLEM                                   SOLUTION                                               TECHNOLOGY AREA
***
* THE HOUSINGS USED IN TACTICAL WEAPONS CONTROL SYS   PROVIDE A COMPUTER NUMERICAL CONTROL (CNC) MULTIMI   FABRICATION CADCAM
TEMS ARE THE SINGLE HIGH COST ITEM IN THE SYSTEM.   SSION CENTER CAPABILITY TO PRODUCE THESE HOUSINGS
 THESE HOUSINGS ARE EXPENSIVE BECAUSE MID VOLUME    AT AN ANNUAL RATE OF 12,000 TO 50,000.
PRODUCTION CAPABILITIES HAVE NOT BEEN ESTABLISHED
*

***
* -----------------------------------------------------------------------------------------------------------------

COMMAND CODE   PROJ NO   TITLE                                                     FY    COST   CYCLE
***
*    5          4136     IMPROVED TEST AND EVALUATION METHODS                      70     100   COMPLETED
*                                                                                  73     418   COMPLETED
*                                                                                  74     465   COMPLETED
*                                                                                  75     283   APPROVED
*                                                                                  76     150   APPROVED

PROBLEM                                   SOLUTION                                               TECHNOLOGY AREA
***
* BECAUSE OF COST, AVAILABILITY OF TESTING FACILITI   INVESTIGATE, EVALUATE, AND APPLY A MATHEMATICAL TE   SIM, MODEL, OP RESCH
ES, ETC., DATA FOR QUALITY ASSURANCE OF MUNITION    CHNIQUE FOR SRAM, ( SAFETY RELIABILITY, AVAILABILI
ITEMS IS LIMITED AND DIFFICULT TO INTERPRET.        TY, AND MAINTAINABILITY AS AN ANALYTICAL AND ASSES
                                                    SMENT TOOL ON PERFORMANCE OF MUNITION ITEMS.

***
* -----------------------------------------------------------------------------------------------------------------

COMMAND CODE   PROJ NO   TITLE                                                     FY    COST   CYCLE
***
*    5          4302     ACCEPTANCE CRITERIA FOR CONTINUOUS SINGLE BASE PROPELLANT 77      75   APPROVED
*                                                                                  76     440   APPROVED

PROBLEM                                   SOLUTION                                               TECHNOLOGY AREA
***
* A LACK OF NON-BALLISTIC ACCEPTANCE AND HOMOGENEIT   IMPROVE THE ACCURACY AND RAPIDITY OF ASSESSMENT AN   SIM, MODEL, OP RESCH
Y LIMITS FOR CONTINUOUSLY PRODUCED PROPELLANTS.     D TO INSURE DESIRED QUALITY BY IDENTIFYING AND CON
                                                    TROLLING ALL IMPORTANT SOURCE MATERIAL AND PROCESS
                                                     PARAMETERS.

***
* -----------------------------------------------------------------------------------------------------------------
```

SECONDARY CADCAM--ACTIVE PROJECTS
09/20/79

```
***
  COMMAND CODE   PROJ NO   TITLE                                                           FY    COST   CYCLE
***
*      5          4303     ACCEPTANCE OF CONTINUOUSLY PRODUCED BLACK POWDER                76     363   APPROVED
*                                                                                          77      60   APPROVED
  PROBLEM                                          SOLUTION                                             TECHNOLOGY AREA
***
* THE LACK OF A QUALITY ASSURANCE SYSTEM IN A CONTI   IMPROVE THE ACCURACY AND RAPIDITY OF ASSESSMENT AN   CONTINUOUS FLOW PROCESS
  NUOUS PROCESS WHICH DEFINES AND ASSURES RELIABLE    D INSURE DESIRED QUALITY BY IDENTIFYING AND CONTRO
  PERFORMANCE OF BLACK POWDER IN END ITEM USE.        LLING ALL IMPORTANT SOURCE MATERIAL AND PROCESS PA
                                                      RAMETERS.
***
* ------------------------------------------------------------------------------------------------------------------

  COMMAND CODE   PROJ NO   TITLE                                                           FY    COST   CYCLE
***
*      5          6640     PROD CONTROL/QA OF SHAPED CHARGE LINER BY AUTO X-RAY ANAL       76     133   APPROVED
*                                                                                          77     165   APPROVED
  PROBLEM                                          SOLUTION                                             TECHNOLOGY AREA
***
* THE CURRENT X-RAY INSPECTION METHOD IS OF QUESTIO   A COMPUTERIZED X-RAY INSPECTION METHOD WILL BE APP   TEST, INSP, EVAL
  NABLE VALUE FOR MONITORING PRODUCTION OR PREDICTI   LIED WHICH CAN AUTOMATICALLY PRODUCE AND EVALUATE
  NG THE BALLISTIC PERFORMANCE OF SHAPED CHARGE LIN   DETAILED GRAIN ORIENTATION TEXTURE MAPS OF THE JET
  ERS.                                                -PRODUCING PORTION OF THE CHARGE LINER.

***
* ------------------------------------------------------------------------------------------------------------------

  COMMAND CODE   PROJ NO   TITLE                                                           FY    COST   CYCLE
***
*      5          6693     BALL PROPELLANT DETERRANT COATING-CAM RELATED                   78     167   APPROVED
*                                                                                          79     171   APPROVED
  PROBLEM                                          SOLUTION                                             TECHNOLOGY AREA
***
* THE PRODUCT OF THE DETERRENT COATING STEP IN BALL   BUILD A MATHEMATICAL MODEL OF THE DETERRING PROCES   CONTINUOUS FLOW PROCESS
   PROPELLANT MANUFACTURING DEMONSTRATES SIGNIFICAN   S AND VALIDATE IT IN PILOT PLANT TESTS USING A PRO
  T VARIABILITY IN CHARGE WEIGHT FROM BATCH TO BATC   GRAMMABLE PROCESS CONTROLLER.
  H.

***
* ------------------------------------------------------------------------------------------------------------------
```

SECONDARY CADCAM--ACTIVE PROJECTS
09/20/79

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
5	6716	DEV COMP-AID MODEL OF FORMING OPERATIONS FOR ARTILLERY MPTS	76	250	COMPLETED
			77	295	APPROVED
			79	306	APPROVED
			81	150	BUDGET

PROBLEM	SOLUTION	TECHNOLOGY AREA
TRIAL AND ERROR METHODS AND THE ABSENCE OF PROVEN AUTOMATED DESIGN TECHNIQUES FOR TOOLING CAUSE UNEXPECTED FAILURES IN FORMING OPERATIONS AND DELAYS IN STARTUP OF AMMUNITION PRODUCTION LINES.	DEVELOP ANALYTICAL MODELS AND AUTOMATED TOOL DESIGN METHODS OF CRITICAL METAL FORMING OPERATIONS. TOOL DESIGNS THUS GENERATED WILL BE TESTED IN A PRODUCTION SETTING TO VERIFY THE COMPUTER MODELS. PROVEN MODELS ARE APPLICABLE TO CURRENT AND FUTURE ITE	SIM, MODEL, OP RESCH

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
6	7589	AUTO TARGETING SYS FOR PRODUCTION TEST OF AUTO WPN + AMMO	75	130	APPROVED

PROBLEM	SOLUTION	TECHNOLOGY AREA
PRESENT SPECIFICATIONS INCLUDE FEW QUANTITATIVE REQUIREMENTS FOR FUNCTIONAL ACCEPTANCE TESTING.	EXTABLISH ACOUSTICAL AUTOMATED TARGETING INSPECTION SYSTEM FOR PRODUCTION TESTING OF AUTOMATIC WEAPONS AND AMMUNITION.	TEST, INSP, EVAL

COMMAND CODE	PROJ NO	TITLE	FY	COST	CYCLE
6	7802	ESTABLISH MACHINE TOOL PERFORMANCE SPECIFICATIONS	78	195	APPROVED
			79	282	APPROVED

PROBLEM	SOLUTION	TECHNOLOGY AREA
PROCUREMENT, ACQUISITION, AND APPLICATION OF NEW AND USED MACHINE TOOLS ARE BOTH PHYSICALLY AND ECOMICALLY INEFFICIENT.	TESTS WILL BE DESIGNED AND PROCEDURES ESTABLISHED FOR TESTING MACHINE TOOLS AND DETERMINING OVERALL PERFORMANCE EFFICIENCY. GUIDELINES WILL BE WRITTEN FOR PROCUREMENT OF MACHINE TOOLS ACCORDING TO SPECIFIC PERFORMANCE REQUIREMENTS AND EFFICIENCIES.	DATA BASE/DATA AUTOMATION

SECONDARY CADCAM--ACTIVE PROJECTS
09/20/79

```
***
  COMMAND CODE   PROJ NO   TITLE                                                      FY    COST   CYCLE
***
*      6           8025    ELECTRONIC PROFILE READOUT GAGE FOR POWDER CHAMBERS         79     106   APPROVED

  PROBLEM                                          SOLUTION                                             TECHNOLOGY AREA
***
* POWDER CHAMBER SIZE IS CHECKED BY 4-6 FLUSH PIN G   USING NEW PROXIMITY SENSING DEVICES 1 LT WEIGHT GA   TEST, INSP, EVAL
  AGES EACH WEIGHING ABOUT 35 LBS. FROM EACH CHECK,   GE WOULD REPLACE THE 4-6 PRESENT GAGES. IT WOULD P
   MACHINE ADJUSTMENTS MUST BE MADE TO MACHINE CHAM   ROVIDE A SIGNAL FOR DIGITAL READOUT AND FOR TOOL C
  BER TO REQUIRED SPEC.                               ONTROL IN LATTER PHASE OF PROJECT.

***
* ------------------------------------------------------------------------------------------------------------
```

APPENDIX F

GLOSSARY

GLOSSARY

AAH	Advanced Attack Helicopter
AAP	Army Ammunition Plant
ADAPT	An NC language which is a subset of APT
ADPE	Automatic Data Processing Equipment
AEC	Atomic Energy Commission
AMC	Army Material Command
AMHS	Automated Material Handling System
AOD	Arsenal Operations Directorate
APSA	Ammunition Procurement Supply Agency
APT	Automatically Programmed Tool
CAD	Computer Aided Design
CAD-E	Computer Aided Design-Engineering
CAM	Computer Aided Manufacturing
CCMES	Cartridge Case Measurement Eject System
CMES	Cartridge Measurement Eject System
CNC	Computerized Numerical Control
CRT	Cathode Ray Tube
CS/CS	Cost Schedule Control System
CV	Computer Vision
DDC	Direct Digital Control
DIPEC	Defense Industrial Plant Equipment Center
DNC	Direct Numerical Control
EIA	Electronic Industries Association
FMS	Flexible Machining Systems
GOCO	Government Owned, Contractor Operator

GLOSSARY (cont'd)

HQ	Head Quarters
IBEA	US Army Industrial Base Engineering Activity
ITT	Illinois Institute of Technology
I/O	Input/Output
K&T	Kearney and Trecker
LAP	Load, Assemble, and Pack
McAuto	McDonnell Douglas Automation Company
MCP	Multi-Processing Control Program
MHS	Material Handling System
MIS	Management Information System
MMT	Manufacturing Methods and Technology
MPTS	Metal Parts
MSMDS	Multi-Station Mechanical Design System
NC	Numerical Controlled
P&IC	Production and Inventory Control
PASLACS	Pilot Automated Shop Loading and Control System
PC	Programmable Controller
PDP	Registered Trademark
PE	Propellants and Explosives
PEQUA	Production Equipment Agency
PLC	Programmable Logic Controller
RDOS	Real-Time Disk Operating System
SA	Small Arms
SAI	Science Applications Incorporated
S&E	Scientific & Engineering
SEA	South East Asia
SCAMP	Smaller Caliber Ammunition Modernization Program

GLOSSARY (cont'd)

UCC University Computing Company

UNIAPT An NC language which is a subset of APT

UTTAS Utility Tactical Transport Aviation System

DARCOM, MAJOR SUBORDINATE COMMANDS

DARCOM - US Army Materiel Development and Readiness Command

ARRADCOM - US Army Armament Research and Development Command

ARRCOM - US Army Armament Materiel Readiness Command

AVRADCOM - US Army Aviation Research and Development Command

CERCOM - US Army Communications and Electronics Materiel Readiness Command

CORADCOM - US Army Communications and Development Command

DESCOM - US Army Depot System Command

ECOM - US Army Electronics Command

ERADCOM - US Army Electronics Research and Development Command

MERADCOM - US Army Mobility Equipment Research and Development Command

MICOM - US Army Missile Command

MIRADCOM - US Army Missile Research and Development Command

MIRCOM - US Army Materiel Readiness Command

NARADCOM - US Army Natick Research and Development Command

TARADCOM - US Army Tank-Automotive Research and Development Command

TARCOM - US Army Tank-Automotive Materiel Readiness Command

TECOM - US Army Test and Evaluation Command

TSARCOM - US Army Support and Aviation Materiel Readiness Command

USAILCOM - US Army International Logistics Command

APPENDIX G

DISTRIBUTION LIST

DRXIB-MT

DISTRIBUTION LIST

Defense Documentation Center, Alexandria, VA 22314

DARCOM, Attn: DRCMT, Mr. Fred Michel
DARCOM, Attn: DRCPP-IF, Major David Sims

Major Subordinate Commands:

Cdr, Army Armament R&D Command (ARRADCOM), Attn: DRDAR-TSF-P, Mr. Stan Hart
Cdr, Army Armament R&D Command (ARRADCOM), Attn: DRDAR-CLJ-B, Mr. K. A. Coulson
Cdr, Army Armament Materiel Readiness Command (ARRCOM), Attn: DRSAR-IR, Mr. A. Zahatko
Cdr, Army Armament Materiel Readiness Command (ARRCOM), Attn: DRSAR-MSE, Mr. T. Frandsen
Cdr, Army Armament Materiel Readiness Command (ARRCOM), Attn: DRSAR-IRW-T, Mr. G. Hall
Cdr, Army Aviation Research & Development Command (AVRADCOM), Attn: DRDAV-EXT, Mr. Dan Haugan
Cdr, Army Communications & Electronics Materiel Readiness Command, Attn: DRSEL-LE-RI, Mr. Joe Endros
Cdr, Army Communications R&D Command (CORADCOM), Attn: DRDCO-AM, Mr. Dave Ruppe
Cdr, Army Communications R&D Command (CORADCOM), Attn: DRDCO-PE-EC-1, Mr. James Kelly
Cdr, Army Depot System Command (DESCOM), Attn: SDSSA-C, Mr. Russel Harris
Cdr, Army Depot System Command (DESCOM), Attn: DRSDS-SI, Mr. Harry Dell
Cdr, Army Electronics R&D Command-HDL (ERADCOM), Attn: DRLHD-IR, Mr. Robert Rosen
Cdr, Army Mobility Equipment R&D Command (MERADCOM), Attn: DRDME-DE, Mr. Bernie Bretz
Cdr, Army Tank-Automotive R&D Command (TARADCOM), Attn: DRDTA-RCKM, Mr. Sam Goodman
Cdr, Army Tank-Automotive Materiel Readiness Command (TARCOM), Attn: DRSTA-ICC, Mr. Chester Zack
Cdr, Army Troop Support & Aviation Command (TSARCOM), Attn: DRSTS-PLEP, Mr. Jim Corwin

Arsenals:

Cdr, RIA, Attn: SARRI-AOE, Mr. Richard Johnson
Cdr, RMA, Attn: SARRM-TOI, Mr. Dave Strang
Cdr, Watervliet Arsenal, Attn: DRDAR/LCB, Mr. Harold Goodheim
Cdr, Watervliet Arsenal, Attn: SARWV-ODP-S, Mr. Dom Ippolito

Army Ammunition Plants:

Cdr, Crane AAP, Attn: SARCN
Cdr, Hawthorne AAP, Attn: SARHW
Cdr, Holston AAP, Attn: SARHO
Cdr, Indiana AAP, Attn: SARIN-EN, Mr. Gary McCloskey
Cdr, Iowa AAP, Attn: SARIO-EN, Mr. George Mathes
Cdr, Kansas AAP. Attn: SARKA
Cdr, Lake City AAP, Attn: SARLC
Cdr, Lone Star AAP, Attn: SARLS-EN, Mr. Larry Henry
Cdr, Longhorn AAP, Attn: SARLO
Cdr, Louisiana AAP, Attn: SARLA
Cdr, McAlester AAP, Attn: SARMC
Cdr, Milan AAP, Attn: SARMI
Cdr, Mississippi AAP, Attn: SARMS
Cdr, Radford AAP, Attn: SARRA-EN, Mr. John Horvath
Cdr, Riverbank AAP, Attn: SARRB-ER, Mr. Don Keith
Cdr, Scranton AAP, Attn: SARSC-EN, Mr. William Haynes
Cdr, Volunteer AAP, Attn: SARVO-CO, Mr. James E. Fry

DRXIB-MT
DISTRIBUTION LIST (Cont'd)

Depots:

Cdr, Anniston Army Depot, Attn: SDSAN
Cdr, Corpus Christi Army Depot, Attn: SDSCC-MPI, Mr. Roy Oliver
Cdr, Letterkenny Army Depot, Attn: SDSLE-MM, Mr. Richard Cordori
Cdr, New Cumberland Army Depot, Attn: SDSNC
Cdr, Red River Army Depot, Attn: SDSRR
Cdr, Sacramento Army Depot, Attn: SDSSA-MPE-4, Mr. William Humenick
Cdr, Seneca Army Depot, Attn: SDSSE
Cdr, Sharpe Army Depot, Attn: SDSSH
Cdr, Sierra Army Depot, Attn: SDSSI
Cdr, Tobyhanna Army Depot, Attn: SDSTO-ME-O, Mr. Robert L. Marmo
Cdr, Tooele Army Depot, Attn: SDSTE-MAS-SB, Mr. Lee Williams

Project/Product Managers, Lab, Schools & Other Installations/Activities:

Cdr, PM for Production Base Modernization & Expansion, Attn: DRCPM-PBM-T, Mr. D. Morlock
Cdr, PM for Production Base Modernization & Expansion, Attn: DRCPM-PBM-I, Mr. D. Vegh
Cdr, Army Management Engineering Training Activity, Attn: DRXOM-SE, Mr. Al Takemoto
Cdr, Army Materials & Mechanics Research Center, Attn: DRXMR-ER, Mr. Roger Gagne
Cdr, Army Maintenance Management Center, Attn: DRXMD-I
Cdr, Joint Military Package Training Center, Attn: DRXPT-A
Cdr, Logistics System Support Activity, Attn: DRXLS-LP
Cdr, Army Research Office, Attn: DRXRO-AO
Cdr, DARCOM Automated Logistics Mangement Systems Activity, Attn: DRXAL-T